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IRRIGATION; WITH AN EXAMPLE OF ITS APPLICATION IN THE ARID REGION OF WESTERN AMERICA.

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I. IRRIGATION.

Irrigation antedates authentic history. This statement is proven by the existence of most wonderful ruins in Asia and Africa, of pools or reservoirs, canals and aqueducts, of the construction and use of which only the most indefinite and unsatisfactory traditions can be obtained. Surmises exist in abundance, but no actual knowledge. These great monuments of hydraulic engineering have excited the wonder and admiration of modern scientists. In fact, until within a generation of the present, no practical advance had been made in the science of irrigation for 3,000 years. Many of the great irrigation works of antiquity were destroyed or abandoned as the results of wars or the convulsions of Nature, and as the ancient local civilization disap-

peared, the lands again became desert, and the small remnants of the races sank into savagery and barbarism.

The extent of some of these great hydraulic works can be conjectured from the ruins remaining. Lake Maeris, in Egypt, was constructed at least 2,000 years before Christ. Its dimensions were sufficient to regulate the annual inundation of the Nile, receiving the surplus waters when there was danger of a flood, and supplying the needed deficiency when the river reached a stage which would not irrigate the crops. This, with other large reservoirs of flood waters, enabled a population of 20,000,000, to exist in the valley of the Nile, while it now supports barely one-fourth of the number.

In ancient times the valleys of the Euphrates and Tigris, now almost a desert, were densely populated. Four thousand years ago the rulers of Assyria had converted those sterile plains and valleys into gardens of extreme productiveness, by the construction of immense artificial lakes for the conservation of the flood waters of the rivers, and great distributing canals for irrigation. One of these canals, supplied by the Tigris, was over 400 miles long and from 200 to 400 feet broad, with sufficient depth for the navigation of the vessels of that time. Throughout Judea the ancient Jews constructed many pools, tanks and wells for the irrigation of their fields. The Greeks of that age also understood the science of hydraulics, as is shown by the remains of great aqueducts. The Phœnicians converted a portion of Northern Africa into fields and gardens by extensive irrigation works. The Romans thoroughly mastered this science and drained the Pontine marshes, supplied Rome with the purest water and developed the agricultural resources of Italy. In France, Spain and Portugal they built aqueducts to supply the cities with water, and canals to irrigate the valleys. In India, tanks, reservoirs and irrigating canals were constructed many centuries before the Christian era, and a great part of that country was kept in the highest state of cultivation. Some of the tanks or artificial lakes covered many square miles, and were often fifty feet in depth. The English Government, in recent years, has re-

opened the ancient irrigating canals, and has built thousands of miles of new ones to prevent the recurrence of the dreadful famines formerly experienced in that densely populated country. About $200,000,000 have been expended on these works, which pay a good interest on the investment through water rentals and the enormously increased revenue from the land taxes. In addition to the millions of acres reclaimed by the government works, each village has its tank, built of masonry and concrete, for domestic and irrigation purposes. The English also found extensive irrigation works in Ceylon, which they have improved and amplified during the last thirty years, thereby greatly increasing the population and revenues.

Most of the canals of China probably antedate the Christian era. They intersect the country in every direction and are used for navigation as well as irrigation. The water is lifted from the canals by primitive pumps or wheels worked by men or oxen. There is no extensive storage of water, although the country is well suited for it. While there are no ancient works in Japan, the entire arable lands, even to the tops of the hills, are most highly cultivated by small community irrigation systems, which conserve all the water from the numerous springs and streams.

America is not without ancient irrigation systems, as is proven by the ruins of extensive canals and large reservoirs found in Peru, Bolivia, Chili and the Argentine. Some of these have been renewed and new works constructed, especially in the Argentine Republic. Evidences exist in New Mexico and Arizona that in prehistoric times, a race now extinct, had extensive irrigation works and cultivated large areas. Some of the Indians in New Mexico, and the Moqui, Maricopa and Pima tribes in Arizona, have lived upon the same lands for hundreds of years by means of primitive systems of irrigation.

The importance of this subject is shown by the fact that more than half the human race subsist upon the products of irrigated lands. To a resident of the humid regions this statement is no doubt startling, but even a cursory investigation will convince him of its truth. The rice-eaters out-

number the wheat-eaters more than two to one, and all rice is grown by irrigation. The hundreds of millions in China, Japan and India live almost entirely on rice.

It is only recently that irrigation has become an important factor in our political economy. As long as the surplus population of the older States could obtain homes on the public domain in the humid regions, no thought of the reclamation of the arid lands was entertained. The insatiable craving for 160-acre farms even led to the settlement of the semi-arid regions of western Kansas and Nebraska, where the rainfall was known to be insufficient and unreliable. The result has been years of suffering and lost efforts, and even appeals to older communities for food. Had the past history of the world been rightly studied by our political economists, these hardy and intelligent pioneers might have been directed to the arid valleys of the great West, where prosperous and independent communities would now exist. But the practice of our farmers has been anything but practical and economical, and intensified cultivation and diversified crops are still repugnant ideas to the great majority of our agriculturists. However, the time has arrived when the problem of our arid lands has become one of the most important before our legislators. The tide which has so long been setting towards the cities must be turned to suburban life if we are to escape social convulsions. There are thousands of intelligent and industrious men anxious for country homes, but without knowledge as to where they can be found. They are told that Uncle Sam's free land is exhausted and, in consequence, when an Indian reservation with poor soil in some semi-arid region, is thrown open to settlement, there are thirty men on the rush line for every homestead. The money spent in reaching the reservation and waiting for the opening would have enabled them to acquire small prosperous homes under some irrigating ditch.

The country must be educated before the congested East will be relieved of its surplus population, and the arid lands of the West be settled. No more important practical and social question confronts us, and the philanthropists, states-

men and editors, should embark in this great educational movement. Already eminent men in Boston and Chicago have begun the formation of societies, similar to Chautauqua circles, to disseminate information regarding this subject, and they should be started in every town and village in the land. It is, no doubt, difficult to interest the residents of the humid regions in this matter; but after their experiences during the past few months, descriptions of the constant genial weather and abundant crops of all kinds in irrigated districts of the West should arouse a veritable enthusiasm and lead to a new crusade in search of homes in the arid regions.

With irrigation, agriculture is made a safe and secure investment. Contrast the life of a farmer under a good irrigation canal with one in the humid regions: the ever-corroding anxiety of the latter, watching and praying for rain while his crops wilt and die, or the sudden blasting of his hopes by storm and flood; while the former, in perfect security, cultivates his crops and turns in the life-giving waters when necessary. Compare, again, the existence of a clerk or mechanic, no matter how good his position, with the owner of twenty acres of unmortgaged irrigated land, cultivated to insure an abundance of nearly everything that his family consumes. The one is a servant with an insecure living, while the other is a virtual sovereign in his security and independence. In no situation in life should there be as much health, happiness, freedom and contentment for the average family as on the little irrigated estate, for their modest wants can be met and their daily bread secured as long as they remain frugal and industrious. The experience of a ministerial friend illustrates so aptly the difference that I may be pardoned for introducing it here. He was making a long bicycle trip, and at midday arrived at the residence of a farmer in western Kansas. He saw in the fields about the house very thriving and abundant crops, in great contrast with the locality through which he had recently passed. Although not in clerical garb, the good man thought that he should put in a word in season, and at the close of the meal, to which he had been invited,

he remarked to his host: "Mr. Brown, I noticed that you have very thrifty and abundant crops. You should be very thankful to divine Providence." The farmer looked at him for a moment and then said: "Stranger, we don't care nothing for Providence here, we're under the company's ditch."

As irrigation is the artificial application of water to land for the purpose of promoting agriculture, it follows, on account of the limited water supply, that only a small proportion of our arid lands can ever be brought under cultivation. But that does not proportionately diminish its economic value in comparison with the much greater area of the humid regions, for, as acre to acre, they are as six or eight to one. In other words, an industrious family on a twenty-acre farm, under an irrigating ditch, will attain a more secure and permanent prosperity than on the usual quarter section of land in the humid regions. In addition to the security of an independent livelihood, the arid regions offer other advantages. The larger amount of sunshine and dryness of the atmosphere conduce to greater healthfulness and more optimistic views of life. The small farm means intensive cultivation and more intelligence, nearer neighbors, less loneliness, greater social advantages, more churches, schools, telephones, electric lights, good roads—in fact, a new civilization with better homes and greater enjoyments than have been known in the older agricultural regions. The resultant man and woman should be a nobler type, with freer, fuller lives than the nervous, careworn, typical American.

Where are these new homes to be found, and how can they be secured? The one-hundredth meridian is virtually the boundary line between the old and the new. The older subjugating conquest of the continent stopped there, except in the localities settled by mineral developments and the narrow humid region along the Pacific Coast. This vast empire was once considered worthless by our statesmen, except for its mineral wealth and as a range for cattle and sheep. And yet this empire offers greater and more prosperous industrial possibilities than any other portion of our

country, because its resources are more varied and extensive. The land of the sage brush and jack rabbit is the most fertile and productive in the world, wherever water can be brought upon it, for nowhere is the soil so rich and the sunshine so constant.

In the arid and sub humid regions the Government still owns 570,000,000 acres. About 20,000,000 acres are in parks and 60,000,000 acres in Indian reservations. There are other lands given to States and private enterprises, but not yet patented, which would reduce the lands open to settlement to about 450,000,000 acres. Of course, the lands given States and corporations can be purchased, and much of the area of the Indian reservations will eventually be thrown open for settlement. A large percentage of this region is mountainous and not arable, and a still larger portion must remain desert and grazing lands from the absence of any known water supply for its reclamation. The most careful estimates of the reclaimable lands, without increasing their cost beyond a profitable figure by expensive reservoirs and canals, is 50,000,000 acres. Other sources of phreatic and artesian supply may be discovered, but it is not probable that more than 60,000,000 acres can ever be brought under cultivation by irrigation. However, that means a new empire, as, under the economic conditions of irrigated farming, that amount of land will support an urban and suburban population of at least 30,000,000 people.

These lands may be assigned to the different States about as follows:

Arizona	2,000,000
California	10,000,000
Colorado	5,000,000
Dakota	1,000,000
Idaho	4,000,000
Kansas	1,000,000
Montana	8,000,000
Nebraska	1,000,000
Nevada	2,000,000
New Mexico	3,000,000
Oregon	2,000,000
Utah	3,000,000
Washington	2,000,000
Wyoming	6,000,000

One result of the reclamation and utilisation of large areas of the arid lands through irrigation will probably be the increase of the rainfall in the sub-humid regions adjoining, to an extent which will render them far more valuable and reliable for the cultivation of the cereal crops. Most of the above acreage is already in private ownership, but as ditch companies hold large areas obtained through the desert law, or purchased from railroad companies, it can be bought at reasonable prices, on long-time payments.

A conservative estimate of the amount of land under ditch is about 25,000,000 acres, and probably one-half of that is under cultivation. Statistics gathered by the Government experts in the last census make the average expense of reclamation $8.15 per acre. The first ditches were built close along streams where the land was comparatively level, and the cost was merely nominal, but in some of the later projects, embracing immense reservoirs and concrete aqueducts, the expense has been $100 per acre. The reclaimable lands not yet under ditch will necessitate much more difficult engineering, and will raise the average price per acre of reclamation very considerably. The average annual return from irrigated lands, according to the census, is $14.87 per acre. This is much lower than it should be, as grass and pasturage lands are included in the estimate. Even that figure is, however, at least three times the average return of all the farms in the country cultivated without irrigation. The value of irrigated lands will soon become so great that in the near future the large ranches now devoted to pasturage and cereal crops will be divided into small holdings, when intensified farming will more than double the annual productiveness, and the estimated average value of $83 per acre.

Riverside, Cal., may be taken as an example of what irrigation will accomplish. The land, in 1870, was rated at $1 per acre. About $100 per acre was expended in bringing water to the lands. It is estimated that the annual return from the citrus orchards is from $200 to $300 per acre, and they have frequently sold as high as $1,000 per acre. Near Fresno, Cal., unimproved sage brush land, under ditch with

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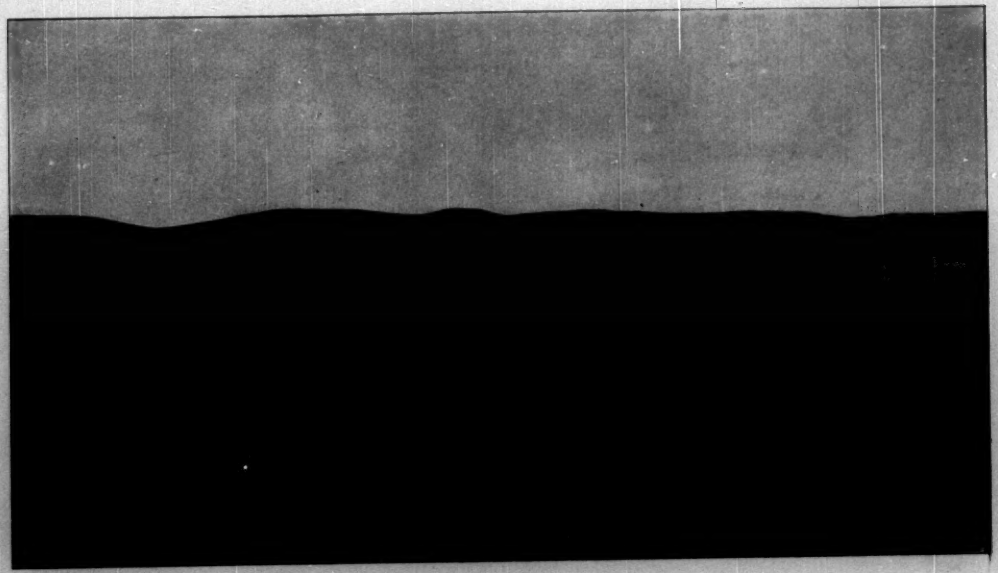
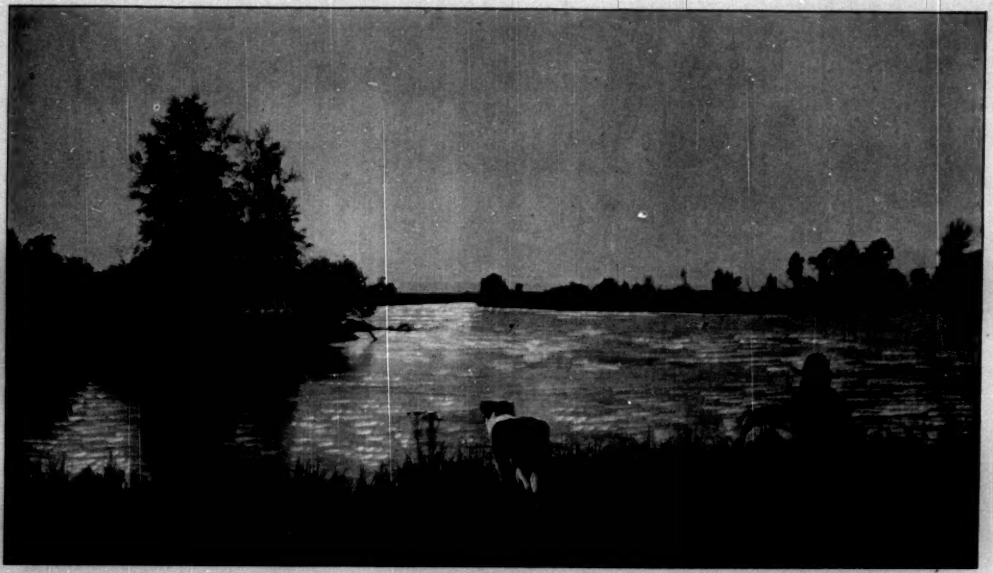


SAGE BRUSH LANDS IN ARID REGION.



THE YAKIMA RIVER, WASH.

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water right, sells from $100 to $300 per acre. Before the day of irrigation it could be bought for $2 per acre. These results are, of course, far above the average, but there are few localities in the arid regions where the crops from irrigated lands, with intensified farming, will not justify an average price of $100 per acre. When it is less, it is due to unusually poor soil, distance from market, or a poor water right. This estimate is made in comparison with the price of improved farms in Illinois or Iowa, and their average annual productiveness. Lands under ditch can now be bought in many localities for less than half that price, and on easy terms; but as the arid regions become settled, the average yield of irrigated lands, even in varied crops, will justify the larger price per acre.

YAKIMA COUNTY, WASHINGTON.

This county lies between latitudes 46° N. and 47° N., and longitudes, 119° W. and 122° W. It contains 5,580 square miles, or 3,571,200 acres, and is somewhat larger than the State of Connecticut. The Columbia River, one of the largest in the United States, borders the county on the north and east for over eighty miles, while the summit of the Cascade Mountains forms its western boundary. The Yakima River has its source in several lakes near the crest of the Cascades, and flows diagonally through the county from northwest to southeast, cutting through several basaltic ridges and the enclosed basins. A number of streams flow into the Yakima, principally from the westward. One of these, the Natchez River, is fed by the glaciers of Mount Ranier, and is almost as large as the Yakima itself above the junction. As is well known, the Cascade Mountains, trending north and south, divide the State of Washington into two nearly equal parts. On the west there is an excessively humid region, with the densest forests of enormous trees reaching from the snow-line down to Puget Sound and the Pacific Ocean. On the east, the descent, at first, is very abrupt, but branching ranges and the foot-hills extend long distances, enclosing valleys, which are heavily wooded at the higher elevations, and merge into sage brush and aridity

at their lower ends. Large streams flow through each of these valleys, furnishing the means for their reclamation.

The Cascade Mountains are composed largely of volcanic rocks. They vary in height from 5,000 to 15,000 feet, the latter for Mount Ranier, probably the highest peak in the United States, except Mount St. Elias, in Alaska. This mountain is situated on the western border of Yakima County, while Mount Adams, nearly 10,000 feet high, is wholly within it. Both are extinct volcanoes, although the volcanic heat is still escaping through fissures in their craters. A number of spurs from the Cascades, from a few hundred to 3,000 feet high, run off to the eastward, gradually diminishing in height as they approach the Columbia River. These usually have a gentle slope on one side, conforming to the dip of the strata of which they are composed, but a bold scarp on the other. It is a question with geologists whether these basaltic ridges have been caused by the cooling of lava streams flowing from the volcanoes, or are the results of fractures of the horizontal strata and uplifts radiating from the mountain range. Their peculiar formation, with gentle slope and abrupt scarp, would appear to confirm the latter theory.

Prof. I. C. Russell, of the Geological Survey, after an examination of this region, concluded that underlying the county was a great series of lava sheets, composed principally of basaltic rocks. As the region of this lava flow is drained by the Columbia River, he named it "Columbia Lava." It occupies an area approximately of 200,000 square miles, and varies in thickness from a few hundred to several thousand feet. The Columbia Lava is not one vast flow, but is composed of many separate flows, sometimes separated by land surfaces which contain the stumps of large trees. This extensive series of volcanic overflows ended in a lacustral period when the whole of eastern Washington and Oregon was one vast lake. Many streams washed mud and sand into it, and active volcanoes strewed it with ashes. This accumulation of sediment went on for ages until it was several hundred feet deep. As these lake accumulations were first examined and described

along the John Day River, in Oregon, they were named the "John Day" system. These lake deposits are unconsolidated sediment, sometimes sufficiently compact to make soft sandstone. The layers of sediment are interbedded with light flows of lava, especially on the lower levels. The great disturbances which pushed up the basaltic ranges and hills have occurred since the deposit of the John Day beds. During the existence of Lake John Day, the climate was variable, but mild, and there was a beautiful flora. After it came the glacial age. The great glaciers of the Cascades and regions farther north did not reach Yakima County, but the melting ice formed a lake, which covered a large part of central Washington. This lake from the small amount of sediment deposited in it and the not clearly marked beach lines caused by its waves, was probably of brief existence. That it covered the lower valleys in Yakima County is certain, as many granite and basaltic boulders are found which must have been brought from much farther north and dropped by melting icebergs floating in the lake.

The last geological episode that occurred in Yakima County was a lava flow of molten rock from the headwaters of the Tiaton Creek, a tributary of the Natchez River. It flowed in an easterly and southeasterly course for some forty miles, ending at the junction of the Natchez and Cowychee Rivers. It was from 200 to 500 feet thick and from one to two miles wide. This flow of molten rock must have occurred after the deposition of the John Day beds and the subsequent upturning of the horizontal strata. Weathering and erosion had cut away the soft lake deposit into drainage lines, one of which this latest overflow followed, forcing farther apart the Natchez and Cowychee Rivers. Unlike the older volcanic deposits, this youngest lava is not a basalt, but a good example of hypersthene andesite.

A topographical description of Yakima County is extremely difficult, because of the great convulsions of Nature which have broken the surface in all directions, and the subsequent weather erosions continuing through many centur-

ies and forming numerous drainage basins. In the extreme eastern part of the county is a triangular plain, about fifty miles long and twenty miles broad at the north. Its elevation in the eastern part is slight, but the plain gradually rises to the westward until it terminates at the Rattlesnake fault, which reaches a height of 2,000 feet above the Columbia River. To the southward of the Yakima River, in the southeastern part of the county, is an elevated plateau sloping away from the high hills to the northwest down to the Columbia River. This plateau is called "Horseheaven," from the abundance of bunch grass, and, being in the Columbia River basin, is much more humid than the remainder of Yakima County. Neither the Rattlesnake nor Horseheaven plains are favorable to the finding of a supply of artesian water, as the strata slope away from great faults on the westward, and are not again upraised to form a catchment basin. From the elevation and situation of the Horseheaven country it will be impossible ever to reclaim it by gravity irrigation, except through the construction of reservoirs to conserve the rainfall. In the western part of the county is a mountainous region, where the numerous streams have their sources. It comprises about 1,000,000 acres, and is covered with a heavy growth of pine, spruce and fir. The remainder of the county contains the irrigable lands, which are found in the Yakima and tributary valleys. As before stated, the Yakima River runs diagonally through the county for 125 miles, and has various tributaries from the westward, each watering considerable valleys. Beginning at the northern end of the county, these are as follows, viz.: Wenas, Natches, Cowiche, Ahtanum, Toppenish and Satus. On the east side of the Yakima lie the large Moxee and Sunnyside valleys, which are without streams, but can be largely watered from the main river.

Geologists have maintained that no artesian basin existed in Yakima County, on account of the very broken condition of the country, caused by frequent volcanic action and upheavals of the earth's crust destroying all regular stratification. Lying in the central part of the county, and east of the river, is the dry Moxee Valley, some twenty-five miles

long and averaging five miles in width. This valley owes its existence to the upheaval of its borders, and has a rapid incline towards the Yakima River. Several thousand acres of fine land in the eastern portion of the valley could not be redeemed by gravity irrigation. In consequence, notwithstanding the unfavorable prognostications, a well was started in 1891, about eight miles from the river, and 200 feet above it. A strong flow of water was struck at a depth of 314 feet, which rose in an open tube twenty-six feet above the surface. Seven flowing wells have since been put down at surface elevations, varying from 1,085 to 1,166 feet above sea level. The most easterly wells found good flows of water at from 300 to 500 feet, while those nearer the river had to go twice as deep. The temperature of the water varies from 65° F. in the shallowest well to 75° F. in the deepest. The dip of the water-bearing strata seems to be about 200 feet to the mile. All of the wells show sections having somewhat similar characteristics, but varying as to depth and material of the different strata. They are throughout John Day beds (gravel, sand, clay, shale, sandstone), interstratified with thin sheets of Columbia lava, except in the extreme easterly wells, which encountered no basalt. It is probable that the records of the borings were not kept with sufficient care to make them thoroughly reliable, but enough data were obtained to show that the stratification is very much broken.

A clear elucidation of the question of the source of this artesian supply, under the circumstances, is quite impossible. The difference in the depth of the several wells, and of the temperature of the water, indicate different sources of supply, but the fact that no flowing water can be obtained at a greater surface elevation than 1,190 feet above the sea, as shown by three unsuccessful attempts, leads to the conclusion that the sources are virtually the same, only affected by peculiar local conditions in each instance. The strata are turned up on edge at the sides of the valley, but the limited rainfall precludes the idea that there is a reservoir supplied by the small catchment on the adjacent ridges, especially as the flow of the wells has continued regular throughout several years. The high temperature and the constant plane

above which the water will not rise, would seem to indicate that the artesian basin is an accidental one, fed through fissures in the Columbia lava. The high temperature of the water may be caused by its deep source, or by the lava through which it passes not having cooled down below the temperature shown. A well drilled about eighteen miles west of the Moxee group, and the same distance from the river on the opposite side, at an elevation of 1,125 feet, went down 630 feet through the John Day beds without encountering any basalt. Water was reached at eighty feet from the surface, but apparently under no pressure. The erosion of the deposits in the Moxee has evidently been much greater than in the Ahtanum Valley. A well sunk 630 feet in the Horse-heaven country, in the southeastern part of the county, struck a thick stratum of basalt at a depth of twenty feet, showing that the surface had been almost entirely denuded of the John Day beds.

The total area of irrigable lands in the county, which can be reclaimed at reasonable cost, amounts to about 650,000 acres. As the Yakima River and all its tributaries have very rapid falls, and are not sunk in deep channels, the construction of irrigating canals is a matter of comparatively small expense. The streams being fed by the springs, snows and glaciers of the Cascade Mountains, the Yakima Valley enjoys the unique advantage of being the only locality in the country which has an ample and unfailing supply of water throughout the crop season. In fact, the superabundance of water has thus far been rather a drawback upon the obtaining of the best results, from the tendency of the farmers, nearly all of whom are unacquainted with proper irrigation methods, to flood their crops with too much moisture. It can be appreciated what this means when it is stated that if every drop of running water were utilised in Nevada and Arizona during the season, there would not be sufficient to irrigate one-half of one per cent. of the arid lands in those States.

The following report, made by the United States Geological Survey, shows the average discharge of the Yakima River, taken near its mouth. During the irrigation season,

from March to November, these amounts should be increased by the water already utilised in existing ditches:

	Cubic Feet per Second.
January	4,030
February	5,111
March	10,786
April	11,460
May	21,500
June	17,930
July	5,090
August	2,480
September	2,248
October	2,662
November	4,874
December	4,412

The following is from the report of Engineer F. H. Newell, of the Geological Survey:

"Comparing the estimated October discharge of the Yakima River with that of other rivers, the remarkably large volume from a relatively small watershed is apparent. This is best shown by the following table, which gives the discharge of various streams for October, 1893, and also in several cases for the same month in preceding years. Opposite to this, for comparison, is placed the area drained, and in the third column the area drained by square miles of catchment. These last figures bring out most strongly the large flow of the stream. All quantities of water are given in second-feet (cubic feet per second of time), equaling about fifty miner's inches, as commonly measured:

	Discharge, Second-Feet.	*Drainage Area, Square Miles.*	*Run-off per Square Mile, Second-Feet.*
Yakima, 1893	2,692	3,300	0·81
W. Gallatin, 1893	576	850	0·68
Yellowstone, 1893	1,630	2,700	0·60
Missouri, 1891	3,511	17,615	0·20
Arkansas, 1890	505	3,060	0·17
Arkansas, 1891	624	3,060	0·20
Arkansas, 1892	511	3,060	0·17
Rio Grande, 1892	259	1,400	0·18
Rio Grande, 1893	263	1,400	0·19
Bear, 1891	980	4,500	0·22
Bear, 1892	780	4,500	0·17
Bear, 1893	737	4,500	0·16

"From the inspection of this table, which might be extended to a far greater length, it is apparent that the canal owners taking water from this stream have far less to fear as regards their water supply than have irrigators in other parts of the arid regions."

The following table is taken from the United States Geological Survey of 1891-92. Since that time the irrigated

States and Territories Employing Irrigation.	Crop Irrigated. Acres.	Per Cent. of Area of Irrigated Crops to Total Land Area.	Total Number of Farms with Irrigated Crops.	Average Size of Irrigated Farm. Acres.	Average First Cost of Water per Acre.	Average Value of Water per Acre as Estimated by Irrigators.	Average Annual Cost of Water per Acre.	Average Cost of Preparing Land for Cultivation per Acre.	Average Value of Land Irrigated per Acre.	Average Value of Products from Irrigated Land per Acre.
Arizona	65,821	0·09	1,075	61	$7 07	$10 58	$1 55	$8 60	$48 68	$13 92
California	—	1·91	13,732	73	15 84	52 28	1 60	22 27	150 00	19 00
Colorado	—	1·34	9,659	91	7 15	28 46	0 79	9 72	67 02	13 12
Idaho	218,249	0·40	4,333	53	4 74	13 18	0 80	9 31	46 50	12 93
Montana	350,582	0·38	3,706	95	4 63	15 84	0 95	8 89	49 90	12 96
Nevada	224,403	0·22	1,167	192	7 58	24 60	0 84	10 57	41 00	12 92
New Mexico	91,745	0·11	3,665	30	5 58	18 30	1 54	11 71	50 98	12 86
Oregon	177,944	0·29	3,150	56	4 64	15 48	0 94	12 59	57 00	13 90
Utah	265,473	0·50	9,724	27	10 55	26 84	0 91	14 85	84 25	18 03
Washington	49,399	0·12	1,050	47	4 03	13 15	0 75	*10 27	30 00	17 19
Total United States	3,564,416	0·09	52,584	67	$8 15	$26 00	$0 99	$12 12	$83 28	$14 89

* NOTE.—This cost of $10.27 has been calculated by including cost of leveling land for irrigation. This is very fluctuating. The cost of clearing the sage brush and repairing fairly level land may be taken at $4 per acre.

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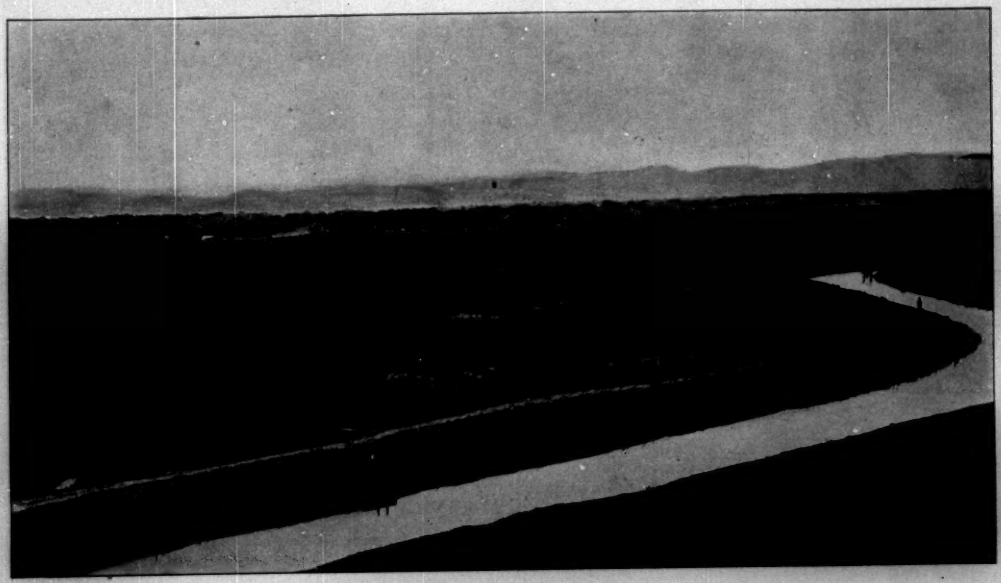
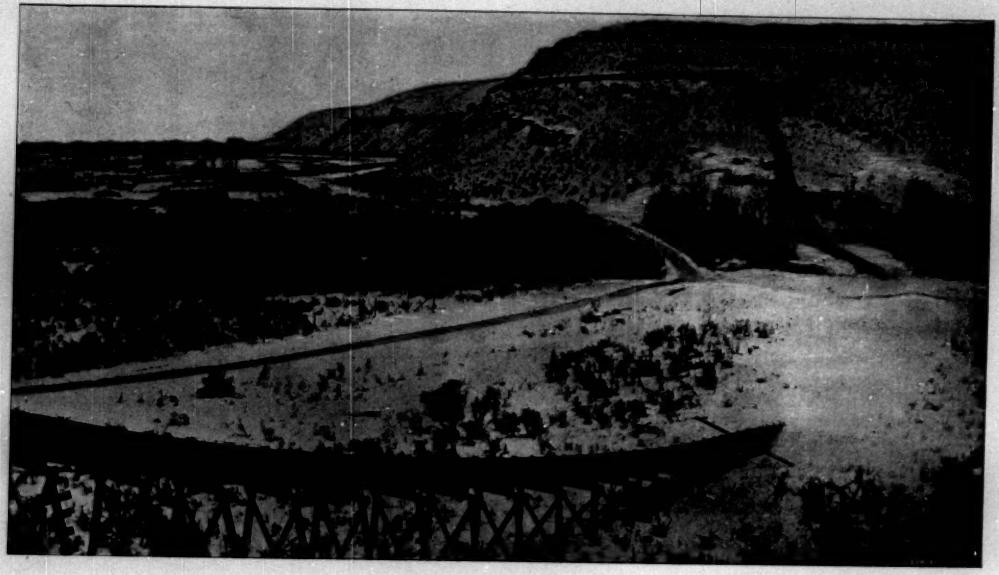


YAKIMA INVESTMENT COMPANY'S CANAL, SUNNYSIDE VALLEY, WASH.



REVERSED SIPHON OF YAKIMA VALLEY CANAL COMPANY, COWICHE VALLEY, WASH.

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crop of Washington has probably doubled, and most of the increase has been in this county. This table proves that the first cost of securing water and the annual expense of maintaining the ditches is less than in any other State, while the percentage of value of crops, as compared with value of land, is much greater.

The Yakima Indian Reservation, containing 887,000 acres, is in the central part of the county, and extends from the Yakima River westward to the summit of the Cascade Mountains. The lands lying along the river are level, rising gently to the westward, and over 100,000 acres can readily be brought under irrigation at moderate expense. Allotments in severalty have been made to the Indians, and it is probable that the remainder of the reservation will soon be thrown open to settlement. As the Indians, about 1,900 in number, are far advanced in civilization and are self-supporting, they are not objectionable neighbors, but, on the contrary, are the most valuable hands that can be employed in the hop fields.

The climate of Yakima County is exceptionally good. The prevailing westerly winds lose their excessive moisture on the crest of the Cascades, so that there are no fogs, but few cloudy days and only about ten inches of annual rainfall. The frost leaves the ground in February, and farming can be begun by the end of that month. The winters are mild and short, with an absence of wind, and almost constant sunshine. The springs are cool, and while there is considerable wind it is purely local, and, on account of the sheltering mountains, never attains any destructive velocity. The summers are long and warm, but with cool nights, while the autumns are very pleasant. During the past six months, while the remainder of the United States has been suffering such extreme vicissitudes of climate, this valley has enjoyed constant delightful weather. The following tables are the reports of the United States weather observers, and are taken at widely separated stations in the county:

MEAN TEMPERATURE.

Location.	*Jan.*	*Feb.*	*Mar.*	*Apr.*	*May.*	*June.*	*July.*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
North Yakima . . .	27	29	43	49	58	65	72	72	59	49	40	30
Fort Simcoe	31	32	42	52	62	66	72	74	64	52	42	33
Kennewick	33	34	51	55	64	70	78	77	64	52	42	33

RAINFALL.

North Yakima . . .	0·85	1·42	1·04	0·96	1·48	0·45	0·25	0·01	0·14	0·58	0·94	1·52
Fort Simcoe	2·14	2·17	1·34	0·74	0·98	0·32	0·19	0·04	0·24	0·81	1·20	2·23
Kennewick	1·58	0·42	0·30	0·39	0·49	0·38	0·02	0·01	0·22	0·54	0·63	1·28

The prevailing hygienic conditions are admirable. There are no sudden changes or cold, piercing winds, and while the summers are long and warm, there are no sultry days, and the cool nights permit refreshing sleep. Farmers can work in the fields the hottest days, and sunstrokes are unknown. The altitude and dryness of the atmosphere prevent the enervating effects of the hot, moist days of humid localities. Local physicians assure me that the climate is beneficial in all asthmatic, pulmonary, bronchitic, neuralgic and rheumatic affections.

The soil consists mostly of sedimentary materials deposited at the bottoms of the lakes, which covered these valleys for centuries, and was at one time of great depth. Weather erosions have removed much of it, but in the valleys it still remains very deep. It is largely disintegrated basaltic rocks, and contains all the chemical elements necessary for great productiveness. While it is porous and absorbs water, yet it has good consistency, is easily worked and does not bake like clayey lands. In Arizona and Mexico this basaltic soil has been under cultivation for 200 years, and does not seem to lose its marvellous fertility. The Pima Indians are known to have cultivated the same lands in Arizona for 500 years, and yet they remain wonderfully productive. The waters from the mountain streams constantly add rich materials to the irrigated lands, and prevent the necessity of ever using artificial fertilizers. The following tables are analyses made by the Department of Chemistry of the State Agricultural College at Pullman, Washington. They show that these soils, from widely separated localities in Yakima County, are especially rich in lime, potash and phosphoric acid, the three constituents most essential to plant life:

	No. 1.	No. 2.	No. 3.
Insoluble silica	64·860	71·670	60·2070
Combined silica	10·185	5·110	18·2270
Soluble silica	·385	·180	·2100
Potash	·700	1·070	·4328
Soda	·700	0·350	·3739
Lime	1·448	2·000	1·2127
Magnesia	·991	1·340	·7880
Peroxide of iron	4·768	6·880	5·1586
Alumina	6·238	7·910	6·8906
Phosphoric acid	·224	0·130	·1007
Sulphuric acid	·129	·020	trace.
Chlorine	·014	trace.	·0058
Water, at 120° C.	1·125	1·510	3·4527
Volatile and organic matter	2·600	1·310	3·0195

There are many irrigation enterprises in the county, and of the 139,400 acres now under ditch, two-thirds were not available for cultivation in the spring of 1893. The financial depression of the last two years has militated against the settlement of the arid regions, and yet the cultivated area and the population of this valley have nearly doubled in that time.

The following table shows the size and cost of ditches, and the amount of land reclaimed and under cultivation:

Canal.	*Length in Miles.*	*Acres Reclaimed.*	*Acres under Cultivation.*	*Cost to Date.*	*Delivered Cubic Feet per Second.*
Gelah Valley Canal Co.	22	6,000	1,000	$84,000	40
Yakima Valley Canal Co.	16	3,000	700	65,000	25
Takoma and Yakima Land Co.	12	—	—	43,000	—
Natchez and Cowychee	7	3,000	3,000	14,000	28
Union Broadgauge and Shauno.	16	5,000	4,500	18,000	45
Moxee Canals (3)	33	5,050	2,500	41,000	140
Moxee Artesian Wells (8)	—	1,500	600	15,000	10
Yakima Investment Co.	42	50,000	10,000	600,000	700
Yakima Irrigating and Imp. Co. (3)	51	17,700	1,100	100,000	329
Prosser Falls Irrigation Co.	8	3,000	400	42,000	28
Prosser-Priests Rapids	18	—	—	72,000	—
Ahtanum Valley (small canals)	100	16,000	16,000	25,000	100
Natchez Valley " "	12	8,000	8,000	6,000	80
Wenas Valley " "	8	4,800	4,800	7,400	36
Cowychee Valley " "	12	4,000	4,000	6,000	35

Nearly all the above are community ditches—that is, the farmers under them have stock in proportion to the number of acres of land which they own, and the service of water is gauged accordingly. A small annual assessment is made to provide for repairs and to hire a ditch-tender. Of course,

the farmers elect their own officers, who have complete charge. The Yakima Investment Company is the principal exception. It owns one of the largest canals in the United States, being thirty feet wide at the bottom, sixty-two feet at the top and over forty miles long. It covers some 50,000 acres in what is known as the Sunnyside, on the east side of the lower Yakima, and takes its water from that river. The annual charge for water is $1.50 per acre. There are no reservoirs in the county, and all are gravity ditches, except the one owned by the Prosser Falls Irrigation Company. This company utilises a small part of the power of the falls in the Yakima, about fifty miles from its mouth, to run two mammoth pumps to elevate sufficient water 100 feet to fill its canal and to irrigate 3,000 acres.

The long, warm summers, with the richest of soils, constant sunshine and abundant water, cause all the products of the temperate zone to thrive luxuriantly. This valley will produce everything that is raised in Southern California, except the lemon and orange, and possibly the fig. The prune, plum, peach, persimmon, pear, apricot, cherry, apple, and quince are grown to a size and with a flavor and keeping quality that is not excelled, if equaled, in any other locality. All kinds of trees are now (July 1st) loaded with fruit, and the limited experience of the past would seem to indicate that the fruit crop can be relied upon. While the trees have to be sprayed to keep them clean of the green aphis, the fruit itself is not attacked by any pests. The past success in growing it gives assurance that a large part of the valley will eventually be devoted to fruit. The quality of the variegated product should make the orchards quite as valuable as the orange groves of Southern California. Small fruits are equally productive, and melons excel in quality and quantity. Every vegetable raised anywhere in the United States can be produced here successfully. The asparagus and celery are especially fine. Potatoes grow to such size and are of such superior quality, that they bid fair to make the Yakima Valley celebrated for this product alone.

Wheat, rye, barley, corn, broom-corn and sorghum are

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VINEYARD AND ORCHARD, YAKIMA VALLEY, WASH.

VIEW NEAR NORTH YAKIMA, WASH.

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all grown, but the value of the land and the production of more profitable crops will always limit the acreage planted to them. As this is about the only locality west of the Rocky Mountains where corn can be brought to maturity, it will always be a fairly profitable crop. Alfalfa, the most ancient of all forage crops, thrives here to perfection. Its roots go down as far as water soaks, and, once started, it continues to yield permanently from six to eight tons to the acre annually. As a forage plant it has no superior; none has greater fat- or milk-producing qualities, and all stock thrive upon it remarkably. As the surrounding hills and mountains are covered with bunch grass, cattle and sheep are fattened on the ranges ten months of the year, and fed alfalfa the remaining two months. Horses, also, do well upon it,

The Yakima Valley probably excels any other locality in the world in the production of hops. The quality is very superior, and the yield per acre about three times that of the fields in New York. The hop louse or aphis troubles all other districts, and necessitates large expenses for frequent spraying. Here the hot sun and dry atmosphere kill the pest early in the season, and it does no injury. The average yield is about 1,700 pounds per acre, but with good cultivation it can be increased to a ton. The large yield, superior quality and relative low cost of production would seem to insure the future of the industry.

North Yakima, the county seat, is a beautiful town of about 4,000 people, centrally situated near the Yakima River, and with all the principal valleys radiating from it like the spokes of a wheel. It is laid out with broad streets and avenues, which are lined with shade trees, and about thirty miles of streams of clear, cool water flow along by the sidewalks. The city has good water-works, an excellent sewerage system and is lighted by electricity. There are eight churches, two large brick school-houses, and several hotels. The business portion is well built up with substantial brick blocks, and a number of stone buildings are now being erected. A quarry of excellent light-colored sandstone has recently been opened in the vicinity, and it is probable that

it will be largely used in the future, both on account of cheapness and appearance. The Commercial Club has commodious quarters and over 100 members. The professions are well represented, and there are four weekly newspapers. As showing the thickly-populated suburban districts, it can be stated, that there are ten school-houses within two miles of the city. North Yakima and the county generally are settled by a superior class of intelligent Americans from the Eastern and Middle States, who have come here to make comfortable, enjoyable homes. In consequence, the social features, schools and churches are quite equal to those in the older communities in New England. There are several small towns in the county, the principal one of which is Prosser, situated at the falls of that name. On account of its situation and manufacturing facilities, it bids fair to become an important place.

The county had a population of 4,500 in 1890, and it has trebled in the last five years.

NORTH YAKIMA, WASH., July, 1895.

ENGINEERING EDUCATION AND THE STATE UNIVERSITY.*

BY WM. S. ALDRICH, University of West Virginia.
(Member of the Society.)

Engineering education is an education for a profession. As such, its first requirement is a liberal education. This broad trend is best given by the pursuit of those studies affording mental discipline while developing a love of learning for its own sake, and capable of giving an added grace to the exercise of future accomplishments. The professional education follows in course. Its distinctively technical features are to be combined with practical work of an educational value. Such will be found in selected exercises and activities from among those required in professional life

* Abstract of a paper read before the Society for the Promotion of Engineering Education, and revised for publication in the *Journal*.

—in office, field, shop and laboratory. Engineering education, while in the domain of science and an art, is itself an art and a science.

ENGINEERING EDUCATION IN A UNIVERSITY.

With these and related considerations before us, it may be inquired whether any one or all of them find a proper environment in a university. Will engineering education thrive in a university atmosphere, or will it be frozen to death? University presidents and renowned engineering professors have so placed themselves on record in this particular that we would fear the fate of any engineering training given within the walls of a university. But what are the facts as we know them to exist in the United States? Education for engineering as a profession has not only been recognized as entitled to, but has actually received and been correspondingly benefited by, a university environment, quite as much so as in the case of law and medicine. After finishing his liberal education, many believe that the student should continue in the university atmosphere while pursuing his technical studies. If there is any variation in the education itself, as well as in its product, it may be desirable or otherwise, according to the emphasis given academic, compared with technical training. Conclusions from first principles and known facts are important when drawn irrespective of known disturbing elements. In no other kind of education will financial considerations enter to change so completely every condition, and alter so entirely every product as in engineering education.

FEDERAL AND STATE AID TO HIGHER EDUCATION.

The extent to which such aid has been given is now matter of history, but educational history,* that is so important and so vital to our subject that any presentation within these brief limits would not be satisfactory to all. The duties and responsibilities of the State in this direction

* "Contributions to American Educational History, No. 9.—The History of Federal and State Aid to Higher Education." By F. W. Blackmar, Ph D. Bureau of Education, Washington, D. C. 1890.

have always been recognized, but chiefly in providing for academic training. Aside from the Government naval and military academies, technical education* received the most promising encouragement from private benefactions till its national endowment by the passage of the famous Land Grant Bill, July 2, 1862.† There were peculiar conditions of national life and growth of educational ideas which led up to the passage of this bill, avowedly for the promotion of scientific and industrial education, rather than what we have considered to be purely technical—much less, professional—from an engineering standpoint.

THE LAND GRANT ACT OF 1862.

The "Colleges of Agriculture and the Mechanic Arts," established pursuant to the provisions of this Act, mark the beginning of a new period and of a peculiarly American development of national aid for promoting scientific and industrial education. Each State received a definite "grant" of 30,000 acres of public lands for each Senator and Representative in Congress—an apportionment probably as equitable as could have then been devised. Differences of population at the time of the "grant" and the natural inequalities of statecraft have shown the folly of some States and the wisdom of others in disposing of their "land scrip." The proceeds were for "the endowment, support and maintenance of at least one college, where the leading object shall be—without excluding other scientific and classical studies, and including military tactics—to teach such branches of learning as are related to agriculture and the mechanic arts, in such manner as the Legislatures of the States may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life."

Agricultural education languished in many States; in-

* "Technical Education in the United States." By Prof. R. H. Thurston. Paper presented at the Chicago meeting (July, 1893) of the American Society of Mechanical Engineers. No. DXLIII, vol. xiv, of the *Transactions*.

† "History of the Agricultural College Land Grant Fund of July 2, 1862." Ithaca, N. Y. 1890. Publication of Cornell University.

struction in the mechanic arts had not yet developed into a science, and its incorporation into such colleges was somewhat incomplete until endowed schools led the way; meanwhile, scientific, classical and military instruction carried the day. The degrees conferred were those of Bachelor of Arts and Bachelor of Science. It will probably be admitted that this bill stimulated private endowments for technical schools, quite as much as it directly benefited engineering education. When mechanic arts or shop training became developed along lines at all educational, about the time of the Centennial Exhibition, it was too late for almost all of these institutions. First cost and yearly maintenance confronted them on the one hand; and, on the other, the conservatism of the management and faculty of these institutions, many of which were already living fully up to their incomes in maintaining the scientific, classical and military instruction required by this Act of 1862.

THE MORRILL ACT OF 1890.

By this second national endowment engineering education is recognized and some form of its development made possible in all of the land grant institutions. Aside from instruction in agriculture and the English language, the remaining branches specified in this Act are: "the mechanic arts, * * * * and the various branches of mathematical, physical, natural and economic science, with special reference to their applications in the industries of life, and to the facilities for such instruction." It seemed destined to endow and maintain courses in the mechanic arts at least. Engineering laboratories appeared in view, and some portion of the annual appropriation might be allotted for maintenance of instruction in this newly-required branch of experimental engineering. If the former Act of 1860 was ahead of its time in seeking to provide for instruction in mechanic arts, surely the latter Act of 1890 was not at all so anticipative of the next development of technical education — that of experimental engineering.

This endowment is from the proceeds of public lands, which the Federal and not the State Government has the

disposition of. Each State receives an equal amount annually, irrespective of population or the possibilities of State development. From the first installment of $15,000, made June 30, 1890, it is increased by $1,000 each year for ten years, after which it is to be maintained at $25,000 annually. These radical differences in the form and bestowal of the two national endowments are not without reason. This fund was for "the more complete endowment and support of the colleges for the benefit of agriculture and the mechanic arts," established under the provisions of the Land Grant Bill of 1862. There are only two ways to realize this: (1) by increasing the salary account; (2) by providing additional facilities for instruction such as apparatus, machinery, text and reference books, stock and material.

The salaries of certain chairs, formerly paid out of State appropriations, have been found to be legitimately payable out of this Morrill fund, as the instruction given by the occupants of such chairs falls within that provided for by the bill. Finding that certain salaries *could* be so drawn did not carry with it the least obligation that they *should* be so paid. The land grant institutions of such States do not receive "more complete endowment." It is increased from Washington but decreased from the State Capitol to the extent of those salaries so paid. It is the State Treasury or some other institution which thereby receives "more complete endowment." In the same year that this was done hundreds of thousands of dollars were appropriated by the Legislature of one and the same State for an insane asylum. Pounds of cure: ounces of prevention. Will not our States suffer from this untoward and unanticipated development of parasitism? In particular, will not engineering education lack the encouragement and development it was destined to receive from this Morrill Act?

The duty of the State, after providing for the liberal education of the young engineer in its land grant institution, is to apportion its resources and adapt its facilities for his technical training so as to best prepare him for the particular professional demands that will inevitably be made upon him in his own State. Now, the parasitism, in refer-

ence to the Morrill fund, is not only most likely to occur, but actually has occurred in just those State institutions in which some such development of old and beginning of new engineering courses had long been deemed the necessary first step towards educating their own sons to develop the State's resources and share in the promotion of its industrial progress.

Distinctions of race or color made by any State in the admission of students to its land-grant institution, will require that State, by the provisions of this Morrill Act, to make "a just and equitable division of the fund to be received under this act between one college for white students and one institution for colored students." This means two faculties, a double equipment and a separate establishment throughout.

Such States need, for developing engineering education, all that the Morrill fund will legitimately provide. If they wish to establish and maintain reputable technical courses, to provide recognized facilities for practical work and experimental engineering, to justify their sons in seeking professional training in their own State institution rather than elsewhere, by offering an engineering education that will be at all comparable to that of other State institutions, the Legislatures of these States will need to make additional appropriations. In some of these States this will be all the more difficult, by reason of the parasitism that has developed already from a spirit of retrenchment in aiding educational work.

Engineering education is much less promoted by the Land Grant Bill of 1862, than by the Morrill Act of 1890, for two principal reasons: (1) The classical and the military instruction provided for by the former are excluded by the latter; (2) instead of the unequal permanent endowments of the former there is an equal annual appropriation given to each State by the latter. The effect of this favorable difference has been felt already in several of the States. It has stimulated private benefactions for the promotion of engineering education. It came, also, at a time when urgently needed to assist in establishing new and rapidly

growing engineering courses and aid in the material equipment for the same, such as in electrical engineering.

STATE AID TO ENGINEERING EDUCATION.

The least the State could do in accepting the Federal endowments was to meet the simple requirements of the law, to purchase, erect and maintain suitable buildings in which the instruction provided for by the general Government could be materialized. The initial and other building appropriations, as well as such made for increasing the facilities for instruction and providing for continued effective maintenance, have placed some of the original land grant colleges and universities in the very front rank among our State institutions.

The establishment of light, heat and power plants by some of the States in their institutions has rendered very material aid to engineering education. These were formerly urged from business reasons alone, such as securing greater economy of installation, maintenance and supervision. It as soon became evident that it would be a great advantage to have all the equipment of such a plant gathered about the engineering shops and laboratories, increasing still further the economy. Not only so, but this whole equipment thereby becomes available, at any time during the college year, for experimental engineering work. This might then be conducted on a more practical and commercial scale than if simple experimental machinery had been alone installed for such work. The State thereby reduces the current and contingent expenses for light, heat and power; and, at the same time, provides admirable facilities for shop and laboratory training in electrical, steam and hydraulic engineering. State pride and competition will enhance still further the great economic and educational value of such power plants; and increased use will be found for light, heat and power as necessary facilities in the development of laboratory methods.

AGRICULTURE AND MECHANIC ARTS.

These have been inseparably connected in the minds of statesmen when planning and developing Federal aid for

such instruction. By the Act of 1887, however, each State sustaining a land grant institution receives $15,000 annually for the establishment and maintenance of an agricultural "experiment station." When it comes to the question of Federal endowments for the promotion of scientific research, statesmen are divided. The direct aid which the "experiment station" has rendered to scientific agriculture has scarcely been less than its indirect benefit to agricultural education. The rapid growth of experimental engineering within the last decade, its recognized value for the determination of engineering data and precedents, its incorporation into the professional courses of almost all American technical schools, bespeak a like consideration for engineering "experiment stations" or laboratories in connection with all land grant institutions.

ENGINEERING "EXPERIMENT STATIONS," OR LABORATORIES.*

The technical equipment of such a laboratory would be of invaluable service in engineering instruction; and this in addition to that of the light, heat and power plant, which it is the duty of the State to establish. Engineering instruments would be standardized and tests of power plants con-

[* Considerable progress has already been made in Germany in the establishment of Mechanical Testing Stations, under the superintendence of a government board. *Engineering* (London) July 19, 1895, in describing "The Mechanical Testing Station at Charlottenburg," accounts for the popularity of the system among manufacturers and buyers on the ground that all articles are tested by competent and impartial men at moderate charges. It is held in equally high esteem by men of science for the prosecution of elaborate investigations requiring costly apparatus. "An official testing station is now to be found in every larger German town, in connection with its university or technical school. Some towns can boast of more than one technical college, and of more than one testing station. * * * Pamphlets are issued, stating the way in which specimens should be selected, handled, packed, etc. They also give a summary of the various tests in use, and the charges made for these. * * * By request, experiments are conducted on the special lines desired; the certificate issued in such a case contains a notification to this effect. * * * The same facilities are offered to firms which frequently consult the testing station. * * * Since 1889, the supervising board of the Prussian testing stations has published 'Mittheilungen' on the work done and the experience gained. These journals contain valuable information, and the apparatus originated in these laboratories can be freely copied."—EDS.]

ducted by disinterested parties. Engineering practice throughout the State would be reciprocally benefited; State laws relating to boiler explosions and engineers' licenses subject to careful supervision; and the duty of the State in protecting life and property from engineering accidents, casualties and negligence receive attention commensurate with that now given, by the agricultural "experiment station," to healthful foods, farm and dairy sanitation, and stock-raising. The State's resources of materials for building and other constructive work, as well as fuels—the prevention of their waste and the utilisation of by-products—would receive careful investigation.

Such a State engineering laboratory should be allowed the same immunities and granted the same privileges and opportunities as the agricultural "experiment station" now enjoys, in properly charging for tests, researches, trials, analyses and other scientific investigations. But beside this it should receive State aid for the publication and interchange of bulletins, quarterly or oftener; and this would add as much to the value and permanency of its year's work in engineering as is now done for the agricultural interests. The accumulation, classification and preservation of engineering literature; records of tests, researches and other investigations; and data for engineering practice and precedent, all would receive an amount of attention that it is almost impossible for individuals, corporations or manufacturing establishments to give. What has been accomplished already, by private munificence, in many of the above lines of engineering, in the shops and laboratories of a few of our leading technical schools, should be repeated, extended and made possible by Federal and State aid in every State college and university.

STATE AND ENDOWED INSTITUTIONS.

There are three classes of institutions in which engineering education receives more or less consideration:

(1) Those dependent entirely upon State and Federal aid.

(2) Those receiving private endowments in addition to Federal and State aid.

(3) Those dependent entirely upon private endowments.

For any particular branch of engineering in any one of these institutions the technical studies of the class-room will be found much the same, while the academic requirements differ widely. The kind and amount of practical work in office, field, shop and laboratory will vary according to the nature and extent of the endowment.

State institutions are created and maintained by the people. They exist for the greatest good to the greatest number of students. Candidates who are unable to enter the Freshman class cannot be turned away. In some of them, preparatory courses must be provided for those who have not had the high-school training of the cities. With few exceptions, tuition is free in all departments to all State students. All who pass the entrance examination must be received, whether faculty and facilities are commensurate or not. If both are alike insufficient, there is no better argument with which to go before the State Legislature for additional appropriations. However technical the instruction may be, it is necessary to bear always in mind the particular needs of the State in whose institution it is given; its natural resources, the traditions and customs of the people, their present and prospective industrial life, all, in fact, which make it necessary to shape engineering education so that it may best fulfil its mission in its own State rather than another.

Many State students enter for one or two years only; very few for a definite four-years' course. This entails a responsibility; but it is likewise an opportunity. More elementary technology in the first two years would open the young man's eyes, arousing an ambition to remain, or, perchance, to return after an absence occasioned by financial stress; and, during this period it would help the student better to earn a living. More practical work before leaving would relieve him of its equivalent after returning. Thus, to leave his educational work for a year or two is not the worst thing that can happen to the young engineering student. Many of them will be State cadets, receiving military instruction and training. This makes possible an

organization and development of practical work in engineering, along such lines as have been worked out at the naval and military academies, in detailing students for the conduct of engineering work, in office, field, shop or laboratory.

Endowed institutions are mainly supported by incomes from their first endowments and by tuition fees. They exist for the greatest good that they are able according to their several abilities to give to those who can pay for it. A high standard of admission may be set and maintained. If in good financial and professional standing they will take only that number of students best adapted to the faculty and facilities for instruction. All students enter for the regular four-years' course, practically by competitive examination. The technical instruction may be carried to any ideal standard. No respects have to be paid to any one community or class of interests, ensuring a purely professional course, with the corresponding degree.

STATE COLLEGES AND UNIVERSITIES.

State colleges of agriculture and the mechanic arts appear capable of a higher development, along certain lines, than the State university. In the former the funds are not apportioned among so many different departments as in the latter, whose aim is too often so to multiply courses as to be worthy at least of the name of a university. Each institution has peculiar advantages and disadvantages from the standpoint of engineering education. The State college is distinctively a school of science. Its courses are arranged, its equipment selected and its faculty appointed with this one object in view. In this respect it approaches the position of the endowed school of science. To add an engineering course in such is to introduce its purely technical features.

In both institutions, old academic courses are abridged to make room for the new engineering studies. The effort is made so to combine the essential requirements of a liberal education with sufficient technical training as to warrant conferring the degree of Bachelor of Science in

Engineering—a combination peculiarly significant of the development of engineering education in our land grant institutions. As State colleges and universities receive endowments equally from the Morrill fund, it would appear that, other things being equal, the college student might in time have larger equipment and more specializing facilities to work with. Such material advantages, however, may be more than offset by his lacking the liberalizing tendencies of the university environment.

FACULTY ORGANIZATION FOR ENGINEERING EDUCATION.

The introduction of engineering education into a State college or university—whether prompted by the ambition of the institution or demanded by the people—will require an organization, pursuant to the Morrill Act, which will be effected by an infusion of new ideas, new methods, new men and new appliances. It cannot be otherwise and succeed. In the evolution of engineering education in the State university, three distinct stages of organization of the teaching staff may be recognized:

(1) Engineering teachers are members of one common faculty under one president.

(2) They are organized as an engineering faculty, similar to the law and medical faculties which usually exist at this period of development.

(3) The organization of the engineering college within the university, with its dean or director, whose duties are related to this college as those of president to the university.

The faculties of State institutions are much less stable than in endowed schools. Aside from political causes, the reasons are obvious. There are engineering ethics and equities in teaching as well as in the practice of the profession. Marked changes are taking place in the development of all educational work. For the governing board to direct the president to distribute the studies among the several professors is to develop such an institution on the plan of the country school, where any man may be expected to teach anything at any time. The most efficient professional

teaching can be done and the most highly developed product obtained by specialization of supervision and thorough departmental organization, of which that of the engineering faculty is the first step in the right direction. The engineering college is a plan of organization falling into line with a form of university management which has been remarkably successful in other branches in European universities. In our State universities, engineering education admits of such an ultimate ideal organization, in which a few have already taken the lead.

ENGINEERING EDUCATION IN A NATIONAL UNIVERSITY.

The national endowments of 1862 and 1890 may alone be sufficient to enable several State institutions to get a start in at least one branch of engineering education. It may be regretted that this is the only source of income for such education in many of them; still, it has been shown that very substantial aid may be rendered by the State in furnishing buildings and in the establishment of a light, heat and power plant for its institution. On the other hand, if these Federal endowments are diverted into other channels, serving to maintain several courses in a university instead of a few in a college, or for an unusual development of agricultural education, or to pay salaries formerly paid out of State appropriations, or to sustain an institution of like grade for colored students, then the State appropriations for engineering education will require to be proportionately increased.

A new national endowment for engineering "experiment stations" or laboratories, to be established in all land-grant institutions, after the manner of the agricultural "experiment stations" (provided for by the Act of 1887), would supply the greatest need of all such institutions, namely, facilities for experimental engineering; and this, in addition to the other reason which has called such "experiment stations" into existence: the value of Federal aid for the promotion of independent scientific research.

The federation of all State colleges and universities into a national university, with its educational centre at Wash-

ington, would place such an institution in the very midst of the most favorable environment for the prosecution of that kind of advanced educational work for which it came into existence.

A select committee approved unanimously and recommended for passage (March 3, 1893) the Senate Bill 3,824, reporting as follows:

"Such an institution only could in any proper sense complete the now incomplete system of American education and most wisely direct all worthy efforts in the field of original research, and utilize the facilities for it so rapidly accumulating at Washington.

"It provides for the establishment of a university of the highest type, resting upon the State universities and other institutions of collegiate rank as they rest upon the high schools and academies—a university whose facilities shall be open to all who are competent to use them, but whose degrees shall be conferred upon such only as have already received a degree from some institution recognized by the university authorities; . . . and, whose several heads of departments are to have advisory and coöperative relations with the heads of Government bureaus for the mutual advantage of the Government itself and the cause of universal science."

AN ACCOUNT OF THE GARDINER LYCEUM, THE FIRST TRADE SCHOOL ESTABLISHED IN THE UNITED STATES.

By John H. Cooper.

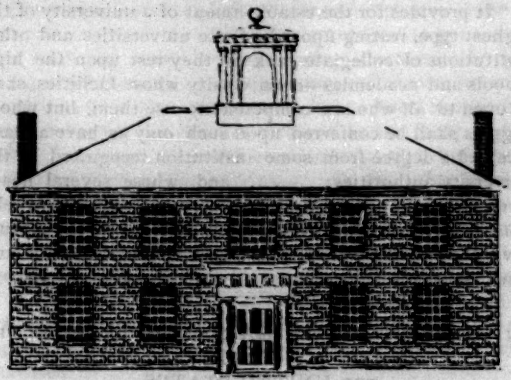
During a winter's sojourn in Gardiner, Me., the writer's curiosity was excited over certain printed and written records, which were placed in his hands by Mr. Geo. M. Holmes.

These records give authentic evidence of an early establishment in that town of a trade school, which was continued successfully for a number of years. The subject of enabling mechanics and farmers to become skilful in their

respective pursuits had occupied the thoughts of the promoters of this new scheme for years prior to a legislative act passed in the year 1821, which paved the way to a public declaration of their intentions, the erection of a stone edifice, and the organization of a school in the year 1822.

These facts place the Gardiner Lyceum first in order of time among trade schools established in the United States.

The originators of this school state that they knew of no organization in existence like the one they had in mind, from which to copy, and therefore they would be compelled to proceed altogether upon original lines.



The Gardiner Lyceum Building. Erected 1822—Burned 1870.

Ancient records teem with statements of results, but they do not always tell us how they were obtained.

From a study of these we are led to the conclusion that the arts and instruction in them very naturally began with the invention of devices and appliances for the collection and preparation of materials for food and clothing, followed closely by means of shelter from the elements and protection from enemies—insect, beast and man—all of which demanded scheming and skill of hand. "Solely intent (says

Rollin) upon the necessities of life, the first inhabitants of the earth did what new colonies are obliged to do."

We have good authority, but have not the space herein at command, for making and commenting upon quotations derived from ancient history, since Bacon says: "The earliest antiquity lies buried in silence and oblivion excepting the remains we have of it in sacred writ."

The writers of these initial chapters have not sounded a single note of preparation for technical work; they come at once, like a creation, to the statement of accomplished facts, leaving our common, enlightened intelligence to draw the inference from our own experience, which may be expressed in few words: "They that *do* shall know."

The history of the human race also abundantly proves the necessity of using head and hands, which are endowed with wonderful and infinite possibilities.

Man was not made for thinking alone; the necessities of existence are ever demanding that hand-work shall co-operate with head-work.

If any one wishes to make something, or to learn an art, there is no question that the best way to do it is for himself to do all the thinking and working necessary to a complete understanding and finishing of it. Bacon has wisely said: "We must familiarize ourselves with things themselves."

Beginning to live, even in our age, we must start with work upon the soil and in house-building, with introduction to the cognate branches of wood- and metal-working, and so the Gardiner Lyceum, recognizing the necessity of better domestic comforts and of advanced knowledge, starts at once the formation of classes in practical farming and carpentry, with promise of expansion into the larger fields of agriculture and architecture, as way may open, and which may be best adapted to the growing needs of their State.

Without further comment, we may now permit the projectors of this first trade school to speak for themselves. Their words have a clear ring, they are single and forcible to the subject, and are full of desire to be broadly useful.

They reached and adopted methods of instruction not even yet surpassed, as they ordained the establishment of a

museum of best working models, economical and practical ways of domestic management, the completion of knowledge by co-operative experimental processes, and moral control by individual responsibility.

Their inaugurals might be read with advantage at the opening of every technical course of instruction in our schools of to-day.

They have sounded the one leading permeating note, present in all our teaching of the science of business and life—the necessity of acquiring expertness of hand with brightness and breadth of intellect.

These early outcroppings of desire—sturdy of growth and full of promise—deserve more than a passing notice, forming, as they do, the safe and solid basis upon which the superstructure of trade, business and the activities of life depend.

If biblical writers thought well enough of trades and tradesmen—"the honorable of the earth"—to salute them with distinctive name and signal notice in their sacred treasury of the Divine word, approved and certain shall we be in transmitting the substance and record of their deeds to the train-teaching of new minds. Wise, indeed, are we, if in our day we plant the seed in good soil and nurture it to a ten-fold and a hundred-fold increase.

PETITION TO THE LEGISLATURE OF THE STATE OF MAINE, FOR THE INCORPORATION OF THE GARDINER LYCEUM.

To the Honorable the Senate, and the Honorable the House of Representatives, of the State of Maine, in Legislature assembled:

The petition of the subscribers respectfully represents that a donation has been offered of land lying on Kennebec River, in the town of Gardiner, estimated at $4,000, for the purpose of establishing within said town a school for teaching mathematics, mechanics, navigation, and those branches of natural philosophy and chemistry which are calculated to make scientific farmers and skilful mechanics. And whereas, it is an object of very great importance to any State, but especially one possessing fine rivers and a fertile soil, numerous mill seats and a coast indented with many and capacious harbors, to a State rapidly increasing in commerce, agriculture and manufactures, that its artisans should possess an education adapted to make them skilful and able to improve the advantages which nature has so lavishly bestowed upon them: And whereas, the State of Maine is in possession of those numerous privileges, yet while she has liberally fostered her colleges

for educating young men for the learned professions, and possesses numerous academies for preparing youth to enter those colleges, and for making useful schoolmasters, she has hitherto omitted to make provision for giving instruction to her seamen, her mechanics and her farmers, upon whom the wealth and prosperity of the State mainly depend. The recent improvements in chemistry, which give the knowledge of the nature of fertile and barren soils, and the best mode of improving them, render the importance of a scientific education to her farmers much greater than at any other period. Your memorialists would further represent that they consider the situation selected for this school extremely advantageous, from its central position in a populous neighborhood, in a fertile country, where provisions are abundant and cheap, where commerce is continually extending, and in a town possessing uncommonly fine mill seats and rapidly increasing in population. They would further represent that, in addition to the donation above referred to, a sufficient sum has been subscribed for erecting a convenient building for the above school; but as a considerable sum will be required for the purchase of instruments necessary for such a school, and as the fees of instruction (in order to make the school generally useful) must be much too low without the income of some permanent fund to give a comfortable support to a person adequate to the task of instruction, they must rely upon the patronage of the State for the power of carrying this plan into effect, notwithstanding the efforts which have already been made.

They therefore pray your honorable bodies to incorporate a school for the above purpose, with a body of seven trustees, with the usual powers and privileges, to be called the Gardiner Lyceum, and to grant such aid as will enable the trustees to bring the school into immediate usefulness.

R. H. Gardiner, Edward Swan,
Peter Grant, John Stone,
Simon Bradstreet, Frederick Allen,
Richard Clay, Sanford Kingsbery.

ACT OF INCORPORATION, PASSED BY THE LEGISLATURE OF THE STATE OF MAINE, JANUARY 30, 1822.

CHAPTER CVIII.

AN ACT TO INCORPORATE THE TRUSTEES OF THE GARDINER LYCEUM.

SECTION 1. Be it enacted by the Senate and House of Representatives, in Legislature assembled,

That an institution, designed to prepare youth, by a scientific education, to become skilful farmers and mechanics, be established in the town of Gardiner, to be called the Gardiner Lyceum; and that Robert Hallowell Gardiner, Peter Grant, Sanford Kingsbery, Frederick Allen, John Stone and Edward Swan, Esquires, be and they are hereby incorporated into a body politic, by the name of the Trustees of the Gardiner Lyceum; and that they and their successors shall be and continue a body politic and incorporate by the same name forever, with all the privileges, and subject to all the liabilities of other similar corporations; and that the number of said trustees shall never be less than five, or more than nine, four of whom shall constitute a quorum for the transaction of business.

SEC. 2. Be it further enacted, That the said trustees shall have power, from time to time, to elect such officers of said corporation as they shall judge necessary or expedient; and shall fix the tenures of their offices; to remove any trustee who may neglect to fulfil the duties of his office; to determine the method of electing said trustees; to fill all vacancies which may arise in said corporation; to determine the manner of notifying their meetings, the time and place where they shall be held; to prescribe the powers and duties of all officers and instructors of said Lyceum, and the course of studies which shall be therein pursued, and the qualifications necessary for admission thereto; *Provided*, that suitable instruction shall always be afforded to those classes of persons for whose peculiar benefit this institution is designed. And said trustees shall have further power to make and ordain any rules and by-laws, with reasonable penalties, for the good government of said Lyceum; *Provided*, that they are not repugnant to the laws of this State.

SEC. 3. Be it further enacted, That the lands, moneys, or other property, which have been already given, offered or subscribed, or which shall be hereafter given, granted, devised, bequeathed, transferred, or assigned to the said trustees, for the purposes aforesaid, or either of them, shall be confirmed to the said trustees and their successors in trust forever; and the said trustees may have and hold, in fee simple, by gift, grant, devise, bequest or otherwise, any land, tenements and hereditaments, and other estate, real or personal; *Provided*, that the clear yearly income thereof shall not exceed the sum of six thousand dollars; and may sell and dispose of the same, and apply the rents, issues and profits thereof in such manner as said trustees shall deem most advisable to promote the design and prosperity of said institution.

SEC. 4. Be it further enacted, That said trustees may have a common seal, and that all deeds sealed therewith, signed, delivered and acknowledged by the secretary of said Lyceum, by order of the trustees, shall be good and valid; and said trustees may sue and be sued, in all actions, real, personal or mixed; and may prosecute and defend the same to final judgment and execution by their said name of incorporation.

SEC. 5. Be it further enacted, That the Legislature of this State (of Maine, G. M. 26) shall have the right to grant any further powers to the said trustees, and to alter, limit or restrain any of the powers vested in them, as shall be judged necessary to promote the best interest of said institution.

SEC. 6. Be it further enacted, That Robert Hallowell Gardiner be and he is hereby authorized to call the first meeting of said trustees, by giving notice of the time and place of said meeting in some public newspaper, printed in the county of Kennebec.

Board of Visitors, appointed under Act of February 6, 1823:

The Governor, Albion K. Paris; the President of the Senate, the Speaker of the House of Representatives, and the following gentlemen, appointed by the Governor: Rev. William Allen, D.D., Brunswick; Rev. Jeremiah Chapem, D.D. Waterville; Hon. Daniel Cony, Augusta; Hon. Benjamin Vaughan, Hallowell; Hon. Ebenezer T. Warner, Hallowell; Hon. Enoch Lincoln, Paris; Thos. G. Thornton, Esq., Saco; Parker Cleavland, Esq., Brunswick; William Ladd, Esq., Minot; Josiah Hook, Jr., Esq, Castine; Nathaniel Gelman, Esq., Waterville.

AN ADDRESS TO THE PUBLIC FROM THE TRUSTEES OF THE GARDINER LYCEUM, BY R. H. GARDINER.

"It will doubtless be remembered by the citizens of this State, that at the last session of the Legislature an institution was incorporated by the name of the *Gardiner Lyceum*, the object of which was stated to be: 'To give to mechanics and farmers such a scientific education as would enable them to become skilful in their professions.' The trustees, having begun an edifice of stone for the use of the Lyceum, and having made arrangements for the commencement of instruction the ensuing winter, think proper to give to the public a more detailed account of the origin of the institution, and of the plan upon which they mean to proceed. The small number of mechanics acquainted with those principles of natural philosophy, upon which the successful operation of their arts depends, has been long a subject of regret.

"To supply this deficiency was the object of the projectors of the Lyceum, and although there was no existing institution to which they could refer as a prototype, yet they felt a confidence that their views were so practical, and so obviously useful, and so easily carried into effect, that they must meet with the approbation of the public. Nor have they hitherto been disappointed. Having obtained what aid they could from the neighborhood where the institution was to be located, they stated their views to the Legislature, and the great benefits which they expected to be derived from the establishment of the Lyceum; but at the same time the inadequacy of their own means to carry it into effect without pecuniary aid from the State.

"An act of incorporation was readily granted; and the trustees, after mature deliberation, determined to do everything upon their part to carry the institution into effect, with confidence that the Legislature, having approved their object and encouraged them to proceed, would not suffer their exertions to be lost, or the public to be deprived of the benefits of so important an institution for want of its fostering aid. Their plan has likewise received the approbation of many gentlemen of intelligence, some of whom have been engaged in the higher departments of instruction themselves, and others of whom have visited the most celebrated places for education in different parts of Europe. They have all thought the institution much wanted, and that, if properly conducted, it could not fail of being highly useful, and of being the means of similar institutions arising in other parts of the country.

"The practical utility of science cannot be doubted in an age where its investigations have produced such astonishing improvements as in the present. There is scarcely an art which has not directly or indirectly received from it important services, for science must necessarily be the foundation of every art.

"Not that the arts originate in the speculations of the philosopher, or cannot be practiced without an acquaintance with science. On the contrary, they frequently owe their beginnings to accident, and the knowledge of the art is but the knowledge of a few insulated facts.

"These facts, observed by the man of science, led him to an investigation of their nature and the laws according to which they are produced. He discovers what is necessary and what is accidental in the process, and thus infers an easier and cheaper mode of arriving at the same result. * * *

"All the sciences which come under the name of natural philosophy are useful. A knowledge of mechanics, which teaches the laws of motion, the general principles upon which all machinery is constructed and operates, and the nature and laws of the various moving forces, is almost indispensably necessary to the practical mechanic who is charged with the care of the construction of machinery. In the construction, it will enable him to accomplish his business with more ease and certainty. The formation of the teeth of wheels and pinions, *e. g.*, so that machines shall neither be retarded by unnecessary friction, nor rendered irregular in their motions, which is difficult to an uneducated mechanic, is made perfectly simple and easy by science. The value of science is particularly felt by the mechanic when anything is to be accomplished out of the common course of his business. Instead of wasting his labors in guessing and trying ill-conceived experiments, the scientific mechanic knows at once where to direct his efforts, and can predict with some degree of certainty the result before the experiment is made.

"All machines are capable of modification and improvement, and it is not so much by the invention of new machines as by the modification of old ones that ingenious mechanics have rendered so much service to the public. * * * But a mechanic must be extensively acquainted with machinery, and the principles upon which it is constructed, before he is able, by slight alterations, to apply machines to new purposes, or so to simplify their construction as to bring into general use those that were otherwise too expensive.

"With a view to furnish to farmers and mechanics the education here represented as so useful, the Gardiner Lyceum has been established, and the course of study will be arranged with a particular reference to the wants of those classes for whose particular benefit it is designed. As soon as suitable apparatus can be procured, lectures will be given upon the sciences there taught, and the application of those sciences to the arts will be illustrated as fully as the nature of the lectures will admit. As fast as the funds of the institution will allow, models will be procured of the best machines employed in the useful arts. Specimens will likewise be collected of the natural productions of the country, as opportunity offers, and they will be deposited in a cabinet in the Lyceum.

"Candidates for admission to the Lyceum will be required to produce certificates of good moral character, and will be examined in the four fundamental operations of arithmetic. * * *

"No student will be required to attend to all the branches of instruction for the second year, but only those which are best adapted to his future wants. He will likewise be instructed in the practical application of the knowledge thus acquired to the particular art which he is to practice.

"Two years will complete what is deemed an essential course, but instruction will be afforded to those who wish to continue their studies another year.

"The price of tuition will be $8 a term. Four students of good talents, but needy, will be admitted without charge. Boarding and lodging can be obtained near the Lyceum at $1.50 per week.

"The trustees consider the location of the Lyceum in the town of Gardiner as peculiarly fortunate, from its central position, on a navigable river, in a populous neighborhood and fertile country, where commerce is continually

extending, and in a town possessing uncommonly fine mill privileges, and which already offers to the student in mechanics the exhibition of a greater variety of machinery moved by water than can be found in any other town in the State. In the first organization of an institution, so novel in its nature, it seemed necessary that the trustees should be selected from its immediate neighborhood, for the convenience of frequent meetings; but this necessity will no longer exist when the institution is fairly in operation; and for the purpose of obtaining the views of different classes of citizens, respecting the management of an institution of such general utility, the trustees have determined to petition the Legislature at their next session to enlarge the Board of Trustees, and to form a Board of Visitors, composed of gentlemen of respectability, but residing principally at a distance, before whom the proceedings of the trustees may be brought at stated periods, and confirmed, modified or annulled as they may deem proper.

"The trustees inform the public that the institution will go into operation early in January, under the auspices of the Rev. Benjamin Hale, recently a tutor in Bowdoin College.

"The trustees conclude their address with expressing their confidence that, as they are engaged in an object calculated to meet the wants of a State which possesses all the requisites for becoming great, and distinguished in agriculture, manufactures and commerce, they shall not want for the support and encouragement of the public. They are engaged in no private enterprise. They expect to profit no particular class of men, but to aid those who form the bone and sinew and muscle of the body politic. They aim at the public good and they hope for the public patronage. * * *

"*Agriculture.*—The trustees have been always desirous of having a farm connected with the institution, upon which the students, whilst enjoying salutary exercise, might practically acquire such a knowledge of agriculture as would be of use to them through life, and at the same time enable them, in an honorable way, to discharge, by their own exertions, part of the expenses of their board. * * * A donation of a small but valuable piece of land has recently been made to the institution near the Lyceum, well adapted to agricultural experiments. * * * As, however, it must be a year or more before the land designed for the farm can be brought into a state fit for agricultural experiments, the trustees wish to mature their plan fully, and have it approved by the Visitors, before they lay it before the public. They now give hints of their design, which will be modified as found expedient. The principal objects which the trustees have in view, in establishing the professorship in connection with a practical farm, are: (1) To give to the future agriculturist the knowledge of those principles of science upon which his future success depends, and to let him see them reduced to practice. (2) To furnish a beneficial employment as recreation. (3) To diminish the expenses of board; and, (4) To try a series of agricultural experiments adapted to the soil and climate of Maine. These experiments will be tried by the students, under the direction of the professor, and will be conducted with as much care and accuracy as the nature of the case will admit.

"The labor on the farm will be altogether voluntary. No student will be obliged to work unless he chooses, but it is presumed that even those who do

not intend to become farmers will find the labor on the farm a pleasant occupation, independent of every other consideration, and, in a moral point of view, the substitution of a pleasing occupation connected with the highest utility for the idle sports of their age, cannot but have an important influence on their future character in life.

"The trustees hope to be able to provide some suitable employment for those young men who may attend the institution with a view of becoming mechanics, by which they may be enabled to discharge their expenses.

"Another object of the trustees is to collect the best models of useful tools and machines. A room will be appropriated to these models, where they will be properly arranged and open to the inspection of the public.

"In conclusion, the trustees will only add that, as public good was the sole motive for establishing the Lyceum, so it is the governing principle in all its measures. The whole plan has been arranged with a single reference to the wants of the public, and encouraged as the trustees have been by the patronage they have already received, by the full approbation of gentlemen distinguished not only for science but for practical views, and by the interest which is kindling through our widely extended country in the improvement of agriculture, manufactures and the arts, they cannot but hope that the first school, which has been established for the express benefit of the farmer and the mechanic, will not be permitted by an enlightened public to languish for encouragement and support. "R. H. GARDINER, per order."

"*Gardiner, November, 1823.*"

"*Continued Progress.*—Since the last address of the trustees was presented to the public, several important measures have been adopted. * * *

"(1) With a view to accommodate those whose business during the summer precludes the possibility of their joining the regular classes in the Lyceum, the trustees have established winter classes, in which they can be taught those branches of science which may be serviceable to them in their respective employments.

"The winter classes already established are in *surveying*, in *navigation*, in *carpentry* and *civil architecture*, *chemistry*.

"(2) Relates to expenses, with suggestions towards reducing them.

"(3) One of the most important subjects which engage the attention of those who have the care of a literary institution is that of its discipline. The common methods, from some cause or other, are in a great degree ineffectual, and the fact that they are so, under the best instructors, leads us to suppose that something wrong exists in the very principle upon which they are founded.

"The method which the trustees have adopted admits the rights of students, and proceeds upon the ground that they have reason and a sense of propriety and of morality, which may properly be brought into use in their government. These principles are always adopted in some degree by judicious instructors, whatever their method. They are made the very foundation of our system. This system is new, and is to be considered as an experiment tried upon the responsibility of the trustees.

"* * * In schools in which the government is wholly in the hands of the officers, and the students have no part but to obey, they are often sub-

jected to regulations of which they are not taught the propriety, or which they consider as unreasonable, and the result is, they look upon their instructors as tyrants, whose laws it is heroism to disobey. Nor is this the worst consequence. The infraction of such laws must be punished, in order to support the authority by which they were made, and will frequently be punished with as much rigor as violations of moral precepts or religious duties, and these two kinds of offences, unlike as they are in their nature, will be classed together.

"It will be difficult to remedy these evils, where the instructors and students are supposed to have different interests, and are acting in opposition to each other. But we believe there are principles in our nature, which, if properly cherished and rightly directed, will lead young persons to use their exertions in favor of good order and good morals. * * * Their sense to honor is too often converted into a principle of obstinacy in their opposition to authority; but it might be so directed as to give firmness to conduct truly honorable. * * *"

"The system of discipline, adopted by the trustees, places a large share of the government of the institution in the hands of the students. It is republican in its spirit. A general committee is elected twice each term by the students, in which one of the instructors usually presides, and by which all the laws are enacted. The Principal has a negative upon these laws. They are carried into execution by officers chosen by the students.

"The trustees are inclined to expect much from this system. The students possess a knowledge of each other's character, which instructors cannot always obtain, but which is very necessary for forming just decisions. * * * The laws, being made by the students, will be thoroughly understood, and the consciousness that they are governed by regulations of their own will prevent all fear of oppression. The confidence which this system reposes in the student has the effect of elevating his character. The exercise which he has in self-government is favorable to a proper self-government in future life, and the part which he acts in this small community evidently prepares him to discharge his duty as a citizen of a free republic.

"The saying of Agesilaus, that 'youth should learn that which will be of most use to them when they become men,' must approve itself to every understanding. * * * We hope that the time is not far distant when it shall be as common for farmers and artisans to prepare themselves for their business by a suitable and thorough education as for lawyers and physicians.

"Such an education would not only lay a foundation for their success, but raise the character of their employments from mere mechanical labor to scientific pursuits, and give them credit which their usefulness merits.

"BENJAMIN HALE."

"*Gardiner, October, 1824.*"

"The trustees also give notice that, by arrangements recently adopted, the opportunities for improvement at the Lyceum are increased, and the advantages extended. Scholars may be admitted at the age of twelve years, and will be required to pursue their studies in a schoolroom, under the personal direction of one of the instructors, until qualified to advance into the higher classes.

"Means are also provided by which such students as chose may devote a portion of the time to earn their own support. It is not, therefore, necessary that a young man should be urged forward faster than his abilities and means will justify.

"A workshop is furnished, where employment will be given to young men desirous of supporting themselves, by which they will be enabled to do so in whole or in part. In the summer a number will be received who will have the opportunity of defraying the expenses of board by labor on the farm.

TUITION FEES.

"Classes in agriculture and in civil architecture and carpentry for the whole term, including fees for lectures, $12.00.

"Class in chemistry, including fees for lectures, $10.00.

"Third class, $5.00 per term.

"First and second classes, $8.00 per term.

"Tuition will be furnished gratis to any meritorious young men unable to pay.

"*Gardiner, November 8, 1827.*"

A letter by Mr. E. Holmes to Mr. P. C. Holmes, dated October 30, 1827, says: "We are making some arrangements to enable you of the 'chip' fraternity to pay for board and tuition by work. If you will come down, I shall want you to take charge of the shop and regulate the whole concern, while handling the tools. If you come, or if you don't come, I want you to look into that lathe which turns lasts, gunstocks and *bureans.* * * *

"I have thought it would be an excellent thing in an establishment to turn spokes to wheels, studs to sleigh bottoms, etc., much more expeditiously than in the old way of shaving them out."

"GARDINER, January 2, 1828.

"The trustees of the Lyceum voted to give you the charge of the carpenter class while in the shop. The term commences to-day."

[NOTE.—This was addressed to Mr. Philip C. Holmes, the founder of the machine shop and gear works now conducted by his sons and others, in Gardiner, Me.]

"GARDINER LYCEUM,
"WINTER CLASSES, 1827–28.

"Classes in carpentry and civil architecture and in agriculture will be admitted November 22d, and a class in chemistry, January 2d, next, each to continue until the third Wednesday in April, 1828. * * * Such of the classes in agriculture and chemistry as desire it will have the privilege of attending with the professor in the laboratory during the preparation of the lectures."

We have not been able to learn definitely how long this school maintained an existence. The only reliable information bearing thereon is that conveyed in a private letter from Mr. Geo. M. Holmes, of the P. C. Holmes Company,

Gardiner, Me., to the author, from which the following extract is printed, viz.:

"The school seems to have been quite successful in its objects, so far as I can learn, during its existence. But it was evidently too far "ahead of the times," and so languished and finally was closed for lack of sufficient support and patronage. As nearly as I can ascertain, this occurred about the year 1832."

ELECTRO-METALLURGY AS APPLIED TO SILVER REFINING AND INCIDENTALLY TO OTHER METALS.*

By George Faunce, B.A.S.,
Superintendent Pennsylvania Lead Company.

The lecturer was introduced by the Secretary of the Institute, and spoke as follows:

Members of the Institute, Ladies and Gentlemen:

How swift is electricity! It hastens on its way with the speed of the lightning. When men began in earnest to investigate its laws, and to make practical application of it to the arts, it seemed as though they became infected sympathetically with this characteristic quality of *hurry*. For the past quarter of a century mankind has been racing tumultuously in the wake of this newest servant of humanity, in the endeavor to subjugate it to ten thousand different uses. Only yesterday it was harnessed to the chariot of human progress, and yet even at the start it is on nearly an even footing with steam. Every day new applications are being made, while old methods and forces are being abandoned.

To-day, a new electrical invention is announced; to-morrow, further progress in the art may render the first useless. Having occasion lately to repair a dynamo that was built about seven years ago, I learned that machines of that type were no longer made. It was hard to recall to mind that such a machine had ever been made; yet, to us, the machine had hardly worn off its novelty.

*A lecture delivered before the Franklin Institute.

It is just this rapid evolution and progress that makes it a thankless task to attempt to publish a book or prepare a lecture on the practice of one of the electrical arts. Before the ink is fairly dry, new inventions may have made the author's words ancient history. One can only catch and record an instantaneous photograph, as it were, of the present condition of the art, content with the prospect that, before it is exposed to public view, it may be behind the times, and interesting only as a bit of history.

It is needless to state that electricity is a wonderful and mysterious force; any attempt to explain its nature, or to give the theories by which the physicists attempt to explain it, would be outside the province of this lecture. Enough to accept it as a potent factor in our lives. You all know the varied ways in which it manifests its presence. It generates heat, sufficient to weld iron or smelt metals. It lights our houses and streets. It sends messages around the world. It carries our words, and very tones, hundreds of miles. It transports our bodies from place to place with a speed to which there appears to be no limit. It can do subtler things than these. At its magic touch, chemical affinities are overcome, and substances are split up into their elements. Thus it manifests itself in the form of heat, light, motion, chemical action, while it is said to aid the growth of plants—attempting to rival the sun in its life-giving powers.

This much by way of prelude. I will now enter upon the subject of the evening's lecture, which is the study of that one, among the various manifestations of electricity, on which the art of electro-metallurgy depends, namely, that force which causes the decomposition and recomposition of chemical compounds. This force is named *electro-chemical force*.

Metallurgy is the art of obtaining metals from their ores, and includes the refining and parting of metals, as well as the smelting of ores; in fact, all processes by which the metals are isolated or set free from accompanying impurities.

Electro-metallurgy, therefore, in its strictest sense, should be defined as the art of obtaining metals from their ores,

by the agency of the electric current. Unfortunately, until recently, the sole practical application of electricity to the isolation of metals has been in the separation and deposition of certain metals, from aqueous solutions of their salts, upon a prepared surface, as in the processes of electroplating and electrotyping. In these processes the finish of the plated articles, or the quality of the deposit, is of the first importance, and not the gaining of the metal.

The term electro-metallurgy, to most persons, is now synonymous with this kind of deposition. It would be better to call these processes *electro-deposition*, since the proper deposition of the desired metal on the surface of the article treated is the sole object aimed at; and to reserve the term electro-metallurgy for its correct signification as the art of recovering metals from their ores, and refining them, by electricity. In the first case, the nature and form of the deposit is everything. In the second case, these are secondary considerations, while the great desideratum is quantity and purity of deposit.

Historical Sketch.—One of the commonest and simplest forms of electro-deposition is shown when one metal is coated with another by simple immersion in a solution of a salt of the latter. For example, iron dipped into a solution of copper becomes coated with copper, while copper receives a deposit of silver when dipped in a solution of silver. Zinc, or aluminum, precipitates lead from its solutions, while lead in turn throws bismuth out of its solutions. The fact of the deposition of copper from its solution by iron is mentioned as early as the fifth century. Palissy, the potter, in the sixteenth century, describes the method of coating copper and iron with silver by immersion in silver solution. Sulzer, in 1752, noticed a taste like that of green vitriol when silver and lead in contact were placed on the tongue.

In 1790, two Dutch physicists decomposed water by means of electrical sparks (obtained by friction). In 1799, Volta made his famous discovery of the production of an electrical current by chemical action; and shortly after produced his "crown of cups," by means of which a continuous current could be produced.

All the curious facts known and noted up to this date had remained simply curiosities in the realm of science, and no practical application of them, so far as we know, had been made. From this time, however (that is, no longer ago than the beginning of the present century), investigators began to record results with increasing frequency, although two score years more were destined to pass before any of their discoveries should bear fruit in actual industrial processes.

I will rehearse some of the discoveries which bear directly on our subject.

In 1800, water was first decomposed by the voltaic current. In 1801, it was noticed that if silver were used as a negative pole in a solution of copper, the silver received a coat of copper which would stand burnishing. During the next few years various observers noticed the liberation of the constituents of various salts at the two poles of the batteries, and Brugnatelli gilded two silver medals, by making them negative poles in a gold solution. Sir Humphrey Davy, in 1807, deposited metallic potassium on platinum by means of a powerful current of 274 cells, which was passed through moistened caustic potash. In 1831, Faraday discovered magneto-electricity, on which discovery depends the principle of all the dynamo machines of to-day. In 1834, he formulated his law of electro-chemical equivalents, which will be referred to later.

In 1836, the Daniell cell for generating electricity was invented. It was the first two-liquid cell, and gave a very constant current. As it is the type of nearly all the batteries now in use, and affords an instructive illustration of the process of electro-deposition, it will be well to describe its construction and action. It consists of an external vessel containing a cylinder of zinc. Inside of the cylinder of zinc is a porous earthenware vessel, and inside of this again is a strip of copper. The inner porous vessel is filled with a solution of sulphate of copper immersing the copper strip. In the external vessel, and immersing the zinc cylinder, is dilute sulphuric acid. The acid slowly dissolves the zinc, forming sulphate of zinc and liberating hydrogen. The hydrogen passes through the porous clay vessel, displaces

the copper of the sulphate of copper, thus forming sulphuric acid. The copper, which is displaced from the sulphate, is deposited on the strip of copper which forms the negative pole of the battery.

From 1837 to 1840, electro-deposition, in the form of electrotyping and electroplating, was brought prominently into notice, and began to be used practically on the commercial scale. For several years, the deposition was performed exclusively by currents generated with batteries, but in 1842, Woolrich took out a patent for the first magneto-electric machine for generating currents for electro-deposition. From that date until 1866, no new principles in electro-deposition were discovered, but some progress was made in the improvement of machines, solutions and other details. In 1866, Elkington, in England, obtained a patent for refining copper by electricity, and this date marks the beginning of the application of the electric current to electro-metallurgy proper. The electrolytic copper refining industry has assumed immense proportions, and following hard upon it have come processes for refining silver-lead, for smelting aluminum and aluminum alloys, as well as numerous processes for extracting metals directly from their ores without the intervention of heat derived from fuel.

Principles.—Before entering upon a description of these processes, it will be well to give a very concise résumé of the principles underlying electro-chemical action.

(1) Whenever electricity is generated, whether by friction, by galvanic action, or by motion in a magnetic field, there is set up a tendency for the electricity to flow from one place to another; *e. g.*, from the positive to the negative pole. This tendency is strong or weak, according to the nature of the generating cause, and is measured by the capability of the current to overcome the various resistances opposed to its flow. This capability of overcoming resistance is called the electro-motive force. It is analogous to the pressure of steam, or to the force of a head of water. A certain E.M.F. will transmit a given quantity of electricity through a given resistance in a second. If the resistance be increased, the same E.M.F. will transmit a certain smaller quantity in a second, and *vice versa*.

The quantity of electricity which passes through a given circuit in a given time is a measure of the intensity of the current. The power of decomposing chemical compounds is proportional to the intensity of the current. Although it is true that a definite minimum E.M.F. is necessary before any decomposition will take place, when this limit is once reached, the quantity of material decomposed in a second will depend entirely on the intensity of the current, and not at all on the E.M.F., which may be increased to any extent without changing the rate of deposition.

The electrical resistance of a conductor of electricity is the property it possesses of impeding the flow of a current through it; that is, of diminishing the quantity of electricity that will pass through it in a given time, when urged by a given E.M.F. The resistance of a conductor is inversely proportional to its section and directly proportional to its length and to its temperature, except that with liquid conductors the resistance decreases with increased temperature. Compared with the metals, liquids have an enormous resistance. The best conductors among liquids have a resistance many thousand times greater than that of the most resisting metal. The relative resistance of liquids is decreased by the presence of acids or metallic salts. The practical unit of E.M.F. is the volt, and is very nearly equal to the E.M.F. of the current generated by one Daniell cell. The unit of intensity is the ampère, and is taken to be that current which will deposit in one second of time 1·12 milligrams of silver. The unit of resistance is the ohm, and is represented by a column of mercury about 3¼ feet long and 1·25 inch square, at 32° F. A current having an E.M.F. of one volt, will transmit a current of one ampère through a resistance of one ohm in one second. Please keep in mind the meanings of these terms—volt, ampère and ohm—and note that the depositing power of a current depends not on the E.M.F., or voltage, of a current, but entirely on its intensity, as shown by the ampèremeter. I emphasise this because I have sometimes found it difficult to convince so-called electrical experts that a high voltage would not answer just as well for depositing purposes as the required number of ampères.

(2) The relation existing between these three factors in any current produced by a given constant cause, is embodied in what is known as Ohm's law, which is as follows:

The intensity of the current, C, is obtained by dividing the E.M.F., E, by the resistance, R, thus:

$$C = \frac{E}{R};$$

whence

$$R = \frac{E}{C},$$

and

$$E = C\,R.$$

By the aid of these formulæ, if any two of these factors are known, the third is easily found. Thus, if the ammeter shows the current through a given circuit to be 100 ampères, while the voltmeter shows an E.M.F. of fifty volts, it is evident at once that the resistance of the circuit is

$$R = \frac{E}{C} = \frac{50}{100} = \tfrac{1}{2} \text{ ohm.}$$

(3) It is essential, in preparing for any industrial process, to know the amount of work that is to be performed. We find that the work done by an electric current is equal, in kilogrammeters, to the product of the ampères by the volts, divided by g, the gravitational acceleration ($= 9{\cdot}81$), or

$$W = \frac{C\,E}{9{\cdot}81}.$$

For example, if a machine generates a current whose E.M.F. is 100 volts, and whose intensity is 200 ampères, it will perform work as follows:

$$W = \frac{100 \times 200}{9{\cdot}81} = 2{,}040 \text{ kilogrammeters;}$$

or, as 75 kilogrammeters $=$ 1 horse-power, the work performed will be 27·2 horse-power.

(4) When a current of electricity passes through certain liquids, it will decompose them. This operation has been termed by Faraday, electrolysis. The liquid in which the

decomposition occurs is called the electrolyte. The electrodes are the conductors immersed in the liquid, the anode being the electrode through which the current enters, and the cathode the one through which it leaves the bath. In order to produce electrolysis, the substance to be decomposed must be a conductor of electricity, and it must be a liquid; *i. e.*, either in solution or in a state of fusion. When decomposition takes place, the hydrogen, metals or bases, flow to the cathodes, while the oxygen, or acids, flow to the anodes. If the anodes are soluble, or attackable by the products of electrolysis, they will be gradually dissolved or oxidised. The accumulation about the anodes of the products of decomposition, and of the oxides formed from the metals of the anodes, interferes considerably with the efficiency of the current, on account of the resulting polarisation, and the tendency to set up currents in a direction opposite to the decomposing current. These effects can be partially prevented by constant agitation of the bath.

(5) Faraday, in 1834, gave us two important laws governing electrolysis:

(*a*) The quantity of substance decomposed in a given time is proportional to the intensity of the current (or the quantity of electricity passing through). A corollary of this law is that, in order to set free a given quantity of any substance, a constant quantity of electricity is required. These two quantities are electro-chemical equivalents.

(*b*) The same current acting at the same time on a series of solutions of various kinds will separate in each solution definite weights of the constituents in the ratio of their chemical equivalents. If, for instance, the current traverses tanks containing, respectively, water, lead acetate and silver nitrate, for each gram of hydrogen set free in the first tank, there will be found, respectively, 103·5 grams of lead and 108 grams of silver in the others.

Various causes operate to interfere with the action of these laws, notably, the secondary currents engendered at the anodes by oxidation, etc.

(6) The work absorbed in decomposing a given substance is equal to the work corresponding to the heat produced by

the recombination of the elements, or ions, of the decomposed substance to form the original compound. As one ampère will decompose constant amounts of an electrolyte with varying E.M.F., it follows that to electrolyse a given compound, it will be necessary to use a certain minimum E.M.F. Whatever be the quantity of electricity that passes through the electrolyte, no decomposition will take place until this E.M.F. is reached. Thus, for example, to decompose water an E.M.F. is required of nearly one and one-half volts; for chloride of zinc, two and one-half volts; for copper sulphate, one and one-quarter volts; for copper nitrate, one and one-sixth volts; for lead nitrate, one and one-half volts; for silver nitrate, only three-eighths volt, etc.

(7) When several metals are in the same solution, that one will be deposited first, which, under existing conditions, is most electro-negative.

The purity of the deposited metal depends on various other conditions, viz.: the acidity of the solution and the amount of other metals present in solution. These other more electro-positive metals are more likely to be deposited in a neutral or alkaline than in an acid solution, and if they are present in too large quantities, they will be thrown down with the negative metal. In a solution containing silver, copper and lead nitrates, the current will not deposit a trace of anything but silver if the proper amount of acid is present, unless the lead and copper get to be considerably in excess of the silver. There is no danger of the deposition of copper even when the solution contains one and one-half times as much copper as silver.

(8) When the anodes are soluble and of the same kind as the deposited metal, as is generally the case in refining by electricity, the work absorbed by the decomposition is exactly replaced by the energy produced by the solution of the anode, and the consequent regeneration of the electrolyte. But this does not mean that no work is required in these electrolytic processes. On the contrary, a large amount of work is absorbed in overcoming the resistance of the circuit, in making up for leakage of electricity, in counteracting polarisation and reversal of the currents, in work-

ing pumps, stirrers, etc.; so that the sum total of work performed, and consequently of power consumed, in these plants is very considerable.

With this very brief review of the facts and laws which directly affect electrolysis, you are prepared to follow me in a description of that process with which I am most familiar, and to take a glance at some of the other allied processes which have lately come into great prominence.

Moebius Process.—The process now in use for the electrolytic separation of silver and gold was patented by Bernard Moebius, about ten years ago. He installed his first plant in Mexico, where he perfected his process and proved its feasibility. He next introduced the process into the Kansas City Refinery; but for some unexplained reason it was very soon abandoned. The next to take hold of the new process was the Pennsylvania Lead Company, which, on the advice of its efficient superintendent, the late F. C. Blake, secured the sole right for the State of Pennsylvania, and erected a complete plant in 1886. The original plant consisted of 49 baths, guaranteed to refine 10,000 ounces of silver per day. Shortly after the completion of the original plant, the capacity of the establishment was doubled by the addition of 49 more baths, making the total guaranteed output 20,000 ounces of silver per day. The process was successful from the beginning and has worked smoothly and continuously, without a day's interruption, up to the present time. It has been so managed as to turn out twice as much as the guaranteed output, or 40,000 ounces per day, and this, with only 84 baths, which is the largest number that can be run continuously.

A small plant was in successful operation for a short time in New York City, but was abandoned, I think, for commercial reasons. Mr. Moebius has recently installed another plant at Piños Altos in Mexico, and has only just completed one at St. Louis. Thus, until very recently, the plant at the Pennsylvania Lead Works, at Pittsburgh, has been the only one in the United States in continued successful operation. And here a few words in explanation of the relative position of this process in the general work of the es-

tablishment. The primary object of the company was the production of refined lead suitable for corroding into white lead. Practically all the lead bullion now produced west of the Mississippi Valley carries more or less silver and gold. In refining the lead bullion, these impurities (for so they are to be considered) must be eliminated. Therefore, treatment of gold and silver becomes an essential part of the business of refining lead. The silver and gold are taken out of the lead by means of zinc, which, when intimately mixed with the lead, takes hold of the precious metals and bears them to the top of the bath. The resulting zinc-silver-lead alloy is skimmed off and subjected to a high heat, by which the zinc is distilled off and recovered by condensation, while the alloy of lead, silver and gold, left from the distillation, is cupelled. By the process of cupellation the lead is oxidised, being converted into litharge, which runs off the metal, leaving finally the alloy of silver and gold in the cupel. This silver-gold alloy (called doré bullion), it was formerly customary to ship to the New York Assay Office, where it was parted at a cost of one cent per ounce. Now it is taken to our own parting-room, which is merely an addition to the regular operations of the company. Although the process is of the nature of a side issue, it has enabled the company to undertake an immense business in the way of refining silver bars from amalgamating mills, and silver sulphides from lixiviation works, which could not have been handled economically without the aid of this, or some other parting process.

The silver is refined on the cupel until it contains not over two per cent. of impurities (lead, copper, bismuth). If more impure silver is treated, there is more or less bother with accumulations of copper and lead in the solutions, with consequent large amounts of by-products, and also increased difficulty in turning out a pure product. When the silver has attained the proper degree of purity, it is cast from the cupel into flat plates about 18 inches long, 10 inches wide and ½ inch thick, weighing 425–475 ounces troy (about 30 pounds avoirdupois). These form the anodes in the electrolytic operation. Each plate has three projections or lugs on one of the long sides. Holes

are punched in these lugs to receive the wires which suspend the plate in the solution. The three supporting wires ($\frac{3}{16}$ inch diameter) are attached to a copper rod 28 inches long and $\frac{1}{2}$ inch in diameter, and then the plates are ready to be placed in the tanks.

The ninety-eight baths are arranged in sets of seven, each set being styled a *tank*. These tanks are made of 2-inch California redwood plank, joined together very carefully. The bottom is lined with sheet rubber. Each tank is 11 feet long, 24 inches wide, and 20 inches deep (inside measure), each separate cell, or bath, being 2 feet long by 18 inches wide.

The electrolyte is a solution of nitrate of silver and nitrate of copper in dilute nitric acid. The acid present is only $\frac{1}{2}$ to 1 per cent. of the solution, as only just enough acid is used to prevent the deposition of copper. The consumption of acid is about one pint every twenty-four hours for each bath. The current is conducted to the baths through rods $\frac{3}{8}$ inch in diameter. The rods connecting the tanks are so arranged that any one or any number of the tanks may be left out of the circuit if desired.

The cathodes are thin sheets of pure silver, 13 x 20 x $\frac{1}{32}$ inches thick, weighing 50 ounces troy ($3\frac{1}{2}$ pounds avoirdupois). These cathodes are rolled in the machine shop of the company, from their own silver. In each bath, four of these cathodes are suspended, alternating with three anodes. The distance between cathodes and anodes is about $1\frac{3}{4}$ inches. The rods which support the cathodes and anodes themselves rest on the main conducting rods, which are arranged horizontally along the sides of the tanks. On the side of the bath where the current enters the anodes, the ends of the cathode wires are insulated by rubber, while on the opposite side the ends of the anode rods are insulated, while the cathode rods are in direct contact with the conductor.

The current from the dynamo has an intensity of 180 ampères. It enters a bath through three anodes, and is, therefore, divided up into three parts, each with an intensity

of 60 ampères. It passes out at each side of each anode, through the solution, to the cathodes, so that the intensity of the current through the solution is 30 ampères. These divisions of the main current pass out through the cathodes and are reunited in the main rod and carried to the next bath. The cells, or baths, are arranged in series, the whole current passing through each bath. Each anode is suspended in a muslin bag, which serves to collect the undissolved metals, which fall in the shape of a black slime. The metals thus caught are all of the gold and bismuth, the greater part of the lead as peroxide, together with some silver and copper. Below this system of anodes, cathodes and bags is stretched, on a box-like frame, a piece of cloth on which is gathered the deposited silver, as it is scraped from the cathodes by wooden "brushes." These brushes straddle the cathodes, hugging close to each surface without touching. They are kept moving to and fro by machinery, and they serve not only to brush off the silver as fast as it is deposited on the cathodes, thus preventing short-circuits, but also, by keeping up a constant agitation of the liquid, to prevent, to a large extent, polarisation and the tendency of the solution to settle into layers.

The principal points covered by the patents of Mr. Moebius relate to these mechanical stirrers, and the bags for collecting the gold slimes.

Now we will suppose that we are running 10 tanks, or 70 baths. The dynamo is made to generate a current of 180 ampères. The voltmeter shows an E.M.F. of about 90 volts. Then, by Ohm's law,

$$(R = \frac{E}{C}),$$

it appears that the resistance of the circuit is $\frac{1}{2}$ ohm, or about ·007 ohm for each bath. The work absorbed by this current is, by our formula,

$$W = \frac{E\,C}{9{\cdot}81 \times 75} = \frac{180 \times 90}{73{\cdot}58} = 22 \text{ horse-power.}$$

The total cathode surface per bath is 10 square feet. The current being 180 ampères, the density of the current will be about 18 ampères per square foot of cathode surface.

The current, in its passage through the solution, decomposes the nitrate of silver. Silver is deposited on the cathodes in the shape of dazzling white, coarse crystals, and nitric acid is formed. This acid attacks the anode, dissolving silver and thus restoring nitrate of silver to the solution. The nitric acid also dissolves the copper and some of the lead, and oxidises the bismuth and the rest of the lead, making products which remain undissolved in the bags.

I have mentioned that the density of the current is 18 ampères per square foot of cathode surface. This is high compared with the density used in copper refining, and is the cause of the loose crystalline deposit, as, with a low current density, the deposit tends to become cohesive. In the case of silver, this crystalline structure is of advantage, as the silver can easily be brushed off and collected at frequent intervals. If it were deposited in a cohesive coating, either a far greater quantity of silver would need to be carried in stock, which would unduly increase the interest charges; or, one would have to be continually remelting old cathodes and making new ones, which would be expensive.

A current of 1 ampère will deposit from a solution of silver nitrate 1·12 milligrams of silver per second; a current of 180 ampères, therefore, will deposit 201·6 milligrams per second. According to the second of Faraday's laws, the same current will deposit equal amounts, simultaneously, in each of the seventy baths; consequently, our current should deposit 14·11 grams per second in the whole series. This amounts to a deposition of 50·8 kilograms per hour, or 1219·28 kilograms per day (=39,205 troy ounces). As the horse-power expended to deposit 50·8 kilograms per hour is about 22, it follows that each kilogram of silver deposited consumes about $\frac{3}{8}$ horse-power per hour ($\frac{1}{6}$ pound per horse-power per hour). Although, theoretically, our 70 baths should deposit 39,205 ounces per day, in practice this yield is not obtained for several reasons:

(1) The anodes have to be drawn up out of the baths, for the purpose of cleaning up the gold and silver. This consumes considerable time each day.

(2) Shorter interruptions of the deposition are necessary for replacing anodes, cleaning connections, examining insulations, etc.

(3) With our small machine, which is not quite large enough for the work put upon it, constant vigilance is necessary to keep the current up to 180 ampères throughout the 24 hours, and, of course, any lowering of the intensity of the current means a proportionate decrease in the output.

The actual working results, day in and day out, will average 33,000 ounces per day for the seventy baths. We could, for a short time, deposit in the whole plant 45,000–50,000 ounces per day; but in the long run it will be found necessary to keep about one-seventh of the tanks under repair all the time.

The labor required in the process is slight. A carpenter is employed constantly in repairing and rebuilding tanks, making brushes, boxes, etc. A mason and a machinist are needed about one day each per week for other repairs. Three men on day turn and one at night are all that are required to do the regular work, which consists of cleaning up and melting the fine silver, preparing the anodes and placing them in the bath at the proper time, cleaning up and refining the gold slimes, melting scrap silver, keeping connections clean and insulations perfect. Each tank is cleaned of silver every other day, and of gold once a week. A full-sized anode is dissolved in about two and one-half days.

The deposited silver, as soon as it is taken from the tanks, is washed thoroughly with hot water, in order to rinse out the copper-bearing solution. It is then melted down in a large plumbago retort, which is capable of holding 18,000 ounces (or 1,200 pounds avoirdupois). The fuel used is natural gas. Each retort melts on the average about 5 tons before breaking.

The fineness of the silver produced is 999—often 999½. Indeed, it would require no effort to produce silver 999½ fine regularly, if it were of any advantage. By repeated washing it is possible to obtain almost absolutely pure silver. We

have furnished it to the mint as fine as 999·85. The gold slimes are melted, granulated and parted by acid. The resulting gold is 996–998 fine.

The electrolyte (of which I show a sample) is of a beautiful green color, due to the presence of 4 per cent. or 5 per cent. of copper. It also contains a small percentage of lead. As has previously been stated, when these three metals are present in nitric solution, the silver (being the most electro-negative) is deposited before the others. So long as the copper and lead are not present in too large quantities, and so long as a proper amount of acid is used, the silver will be deposited in a state of absolute purity. As the copper and lead accumulate to a dangerous degree, it becomes necessary to withdraw part of the solution, and, after throwing out the silver with salt, to precipitate the copper and lead.

With large percentages of copper in the anodes, we have not been able to obtain silver fine enough to ship to the mint. Mr. Moebius, in his Mexican plants, has, I believe, treated bullion carrying 30 per cent. to 40 per cent. copper. But it is to be noted that the Mexican mint is not as strict as our own, and is satisfied to take silver containing 10 per cent. copper.

In 1891, the production of electrolytic silver in the United States was about 8,000,000 ounces, or about 13 per cent. of the total production. The production of 1892 will exceed this somewhat, owing to the adoption of the process at St. Louis, and to increased output of the Pennsylvania Lead Company. It will exceed 10,000,000 ounces.

Copper.—Shortly after Elkington obtained a patent for his process for the electrolytic refining of copper in 1866, copper refiners in various parts of the world began to adopt it, especially in England and Germany. In these countries there are plants that have been in operation more than a score of years. At the present time, the copper production of Germany at least is almost entirely refined by the electrolytic process. More recently modifications of this process have been very generally introduced into this country,

until now practically all the refining of argentiferous copper is done by electricity.

In 1890, the estimated production of electrolytic copper in the United States amounted to 24,000,000 pounds, or about one-eleventh of the entire production of the country. In 1891 the amount increased to 36,000,000 pounds, or about one-eighth of the total product.

In 1892 it is estimated that at least 50,000,000 pounds, probably one-sixth of the entire output of the United States, will be deposited by electricity.

In the near future the immense output of the Anaconda mills (heretofore sent across the water) will be treated in this country, and still further increase the percentage of electrolytic copper.

The process is now in operation in fifteen to twenty refineries in the United States. The largest of these are:

The Baltimore Copper Smelting and Rolling Company, Baltimore, Md.; Balbach Smelting and Refining Company, Newark, N. J.; Boston and Montana Copper and Silver Mining Company, Great Falls, Mont.; Bridgeport Copper Company, Bridgeport, Conn.; Anaconda Mining Company, Anaconda, Mont.; Baltimore Refining Company, Baltimore, Md.; Chicago Copper Refining Company, Blue Island, Ill.; Lewisohn Bros., Pawtucket, R. I.

The total estimated capacity of all the electrolytic plants aggregates 4,000 tons per month, that is, these works running full could refine about twice as much as the estimated electrolytic production of the present year.

The general principles involved in this process are the same as those upon which silver deposition depends. The electrolyte in this case is a solution of sulphate of copper. Plates of impure copper (95 per cent. to 98 per cent.) form the soluble anodes, while the cathodes are thin sheets of pure copper. In two important modifications, called Smith's and Hayden's processes, the plate of blister copper answers as both anode and cathode. In Smith's process the plates are arranged horizontally, and the current causes the solution of copper from the under side of each plate, and a corresponding deposit on the upper side of the

plate below. This upper surface receives a coating of wax, or paraffine, which prevents the deposit from cohering firmly to the impure copper. Cotton screens are placed between the plates to catch the undissolved metals. Hayden's process differs from Smith's in having the plates suspended vertically, as in the Moebius process, and in having no screens between the plates.

The copper, on account of the low density of the current, is deposited in a coherent layer in the form of a skin—not in loose crystals. In some of those plants in which pure copper is used as cathodes, these "skins" are peeled off as soon as they are thick enough to bear their own weight, and are used as cathodes. When the copper deposit has reached a certain thickness, the cathodes are removed from the bath and melted for shipment. The impurities (lead, silver, gold, arsenic and antimony) remain undissolved, drop to the bottom and are regularly cleaned up and refined. Iron and nickel go into solution, but are not deposited, being electro-positive compared with copper. The arrangement of the baths varies in different establishments. In some they are arranged entirely in series, *i. e.*, the whole current traverses each bath; in others, the current from the dynamo is divided into several parts, each traversing a set of baths arranged in series.

A striking difference between a silver electrolytic plant and one for copper, lies in the size of the electrodes and the number in each bath, as well as the number of baths. The anodes may be 36 inches long by 24 inches wide and 1 inch thick, weighing over 300 pounds each. The number of anodes in each bath varies from 16 to 18 up to 100. The number of baths in the larger works is from 200 to upwards of 400. Thus, an enormous quantity of metal is held in stock, compared with amount required in the Moebius process. By thus increasing the size of the electrodes, and the number in each bath, the resistance is proportionally decreased, causing a smaller expenditure of power for the same amount of copper deposited. The interest charges are of course increased. Each plant must decide for itself how far it can afford to decrease

the consumption of power by increasing the quantity of metal carried in stock. Some of the large anodes require two months to dissolve, while the cathodes are left undisturbed between two and three weeks.

In order to deposit copper in large quantities daily, as is necessary in these days of fierce competition, currents of great intensity are used. On account of the low resistance, the E.M.F. required is low also. Some of the machines in use generate a current of 3,000 ampères, which means a deposition of about 8 pounds per hour for each bath in a series. The greater number, however, use a current of 1,000–2,000 ampères. The E.M.F. varies from 6–100 volts, one or two machines going as high as 150. The anodes in this process are produced by a series of treatments of ores and mattes by fire. A large part of the cost of producing copper lies in this preliminary treatment.

Lately, two processes have come into use in Germany, which do away with fire, and which appear to be successful in obtaining an electrolyte directly from the ore in the wet way. The two processes are similar in principle, differing only in solvents used and in minor details. It is claimed that by these processes, low-grade copper ores which have never repaid treatment can now be treated at a profit.

In the Siemens process, the pulverized ore, or matte, is leached with a solution of neutral ferric sulphate, which has the property of converting cupric and cuprous sulphide, as well as metallic copper, into cupric sulphate, which is dissolved. In the operation, the ferric sulphate is changed to ferrous sulphate. This solution of ferrous sulphate and sulphate of copper is conducted to the electrolytic tanks, where it serves as electrolyte. At this point a small amount of sulphuric acid is added. The anodes are carbon, consequently insoluble. The solution from the leaching vats is fed continuously into the cathode chamber, where the copper is deposited. Thence it passes to the anode chamber where the oxygen set free by electrolysis converts the ferrous sulphate into basic ferric sulphate. It is thus that the polarisation, which is generally excessive where insoluble anodes are used, is overcome. The free sulphuric acid in the solu-

tion converts the basic ferric sulphate into neutral ferric sulphate, and the process of regeneration is complete. The solution, as it leaves the electrolytic tanks, is pumped up and used for leaching a fresh portion of ore.

In Hoepfner's process, the solvent is a solution of cupric chloride in strong brine, or in a concentrated solution of chloride of lime. This solution will dissolve the sulphide of copper and silver, with precipitation of sulphur and conversion of the copper salts into cuprous chloride. From cuprous chloride solution, nearly twice as much copper is deposited by a given current as from a solution of the sulphate. As in the other process, this solution is fed continuously into the cathode chamber, where the copper is completely precipitated. An equal amount of this same solution is fed simultaneously into the anode chamber, where the liberated chlorine converts cuprous chloride into cupric chloride. The solutions coming from both chambers are mixed together, thus regenerating the original solution.

It is stated that Siemens' process is in use in only one plant near Berlin, but that Hoepfner's process has been adopted at three places in Germany. It is quite likely that this process may soon come into prominence and mark another decided advance in the metallurgy of copper.*

Aluminum.—In no department of metallurgy has electricity achieved so great a success as in the production of aluminum. It has fairly monopolised the whole field, and driven the old chemical processes out of existence. Indeed, before the advent of electrical methods, aluminum was so

* From vol. iii, of Rothwell's "Mineral Industry:"—The production of electrolytic copper in the United States, in 1894, is given as 115,000,000 pounds. The old-established refineries, such as those of the Balbach Smelting and Refining Company, the Baltimore Electrolytic Company, and the Bridgeport Copper Company, increased their output, and several new works have been started or enlarged. Among the latter may be mentioned the works of the Nichols Chemical Company, at New York; the Boston and Montana Company, at Great Falls; and the electrolytic works of the Anaconda Company, at Anaconda, which were remodeled in 1894 on the Thofehru plan; the works building at Salt Lake City, embracing a Bessemer and an electrolytic plant; and the large works of the Guggenheim Brothers, under construction near Perth Amboy, N. J. W.

expensive as to preclude its use in the arts, and the whole development of the aluminum industry may truthfully be credited to electricity. In 1855, when it was first produced in quantity, it was valued at $90 per pound. As methods were improved, the price gradually fell to $5, in 1887. In 1888, the Pittsburgh Reduction Company began to produce pure aluminum by electricity, and placed it on the market at $2 per pound. At present, the metal is quoted at 50 to 65 cents per pound, according to purity. The total world production, from 1860 to 1889, inclusive, is estimated, by Mr. R. L. Packard, at 232,000 pounds. During 1890 and 1891 alone, the production in the United States amounted to 258,000 pounds. These figures show what a revolution has been wrought by electricity in this field.

It is not my intention to enter into a detailed description of the processes in use, but I will simply mention some of the points wherein they differ from the processes already described.

The one great difference is the condition of the electrolyte. Hitherto we have spoken only of solutions. The electrolyte in the aluminum bath is in a state of fusion. It consists of a solution of alumina (artificially prepared from the ore) in molten cryolite, which is a double fluoride of aluminum and sodium. The electrodes are of carbon, and the passage of the current through the electrolyte generates sufficient heat to keep it melted. An enormous quantity of power is absorbed in this process, amounting, according to Mr. Hunt, the president of the company, to 22 horse-power per pound per hour.

The principal producers of aluminum and alloys in the world are: The Cowles Syndicate Company, England; The Metal Reduction Syndicate, England; The Alum. Industrié Actien Gesellschaft, Switzerland; The Cowles Electric Smelting and Aluminum Company, Lockport, N. Y., and The Pittsburgh Reduction Company, Pittsburgh, Pa.*

* Since the delivery of this lecture there have been no radical changes in the metallurgy of aluminum. The electrolytic method of production still maintains its supremacy, and the entire product is thus manufactured. The Pittsburgh Reduction Company is at present the sole producer of the pure metal in the United States. This company has just put in operation an

Lead.—Mr. N. S. Keith has patented a process for refining lead bullion, in which the method of treatment is very similar to that used in copper refining. The anodes are plates of impure lead, the electrolyte is a solution of sulphate of lead in acetate of soda. The process was entirely successful, mechanically and metallurgically, but the cost of treatment was too great, and the large works erected in New York were abandoned. It is probable this process will again be heard from in the days of cheap electricity.

Considerable interest has been manifested in electrolytic processes for recovering zinc from its ores, but nothing of value has yet been attained in that direction. Zinc is so cheaply produced by fire, the energy necessary for its electrolysis is so great, that it does not seem likely that these attempts will be financially successful in the near future.

To summarise: we have found that, within the last two decades, electricity has entered the metallurgical arena, and has achieved for itself the refining of one-sixth of the copper and silver produced in the United States (not to mention the Old World) and the production of the world's entire output of aluminum.

The processes thus far mentioned constitute about all the electro-metallurgical processes in general use at the present time. Numerous patents have been granted on processes for electrolytic treatment of various kinds of ores and for refining metals, but as yet they have met with no great success. As electricity becomes cheaper, however, there is every reason to believe it will play an increasingly important part in the metallurgical arts.

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extensive electric plant for the metal at Niagara Falls. These works will be able to utilise 5,000 horse-power.

In Europe, the Aluminium Industrie Gesellschaft, at Neuhausen (Switzerland), continues to be the largest producer. Dr. J. W. Richards estimates the world's production of the metal, in 1894, at 2,246,000 pounds, valued at $1,123,000. Of this amount there were produced in the United States 706,000 pounds, or about 30 per cent. The production of 1894 was nearly double that of 1893. The selling price of the metal in the United States was from 50 to 63 cents per pound, according to size of order and quality. Taking into consideration the large increase in the capacity of European and American works, lately made or in course of extension, the same authority believes that the production of aluminum in 1895 will be in the neighborhood of 8,000,000 pounds, or 4,000 net tons. W.

NOTES AND COMMENTS.†

SELF-PROPELLING VEHICLES.

The following editorial expressions, which we reprint from a recent impression of the *Electrical Engineer*, besides giving a very sensible summary of this interesting subject, contain one highly suggestive reference to the possible utilisation of the trolley system in connection with the development of this species of road travel, which may be as new to our readers as to ourselves, viz.:

"There is, perhaps, no country in the world where art, science and industry are so much encouraged by the awarding of prizes for meritorious work and progress as in France; and although it might possibly be argued that no invention or appliance of the first order of importance was ever the direct outcome of a prize competition, still it is not to be denied that the origin of many advances can be traced to the stimulus of a prize competition. Even if such competitions do not always result directly in bringing out the desired improvement, they nevertheless draw attention prominently to the object in view, and set to work many who would otherwise remain passive, if not in total ignorance of the needs of the times. We are led to these reflections in contemplating the results of the late self-propelled vehicle competition over the road between Paris and Bordeaux and return, which has attracted more than an ordinary amount of attention, and deservedly, as it touches so closely the question of cheap and rapid transportation. To look upon the results of this competition merely in the light of a race organised by wealthy amateurs with a fad, is to ignore the philosophy of the history of transportation, and more particularly the most recent part of that history, as embodied in the annals of the electric railway for the last ten years.

"The horse has already been practically banished from the streets of American cities as a popular means of passenger transportation, and gradually, but surely, the rest of the world will follow American example. But the highway and country road still afford an asylum to the horse; yet even here, as the recent contest in France has shown, he is not safe from competition.

"The result of the race demonstrated the remarkable qualities of the petroleum motor over a course covering such a distance, and must have been a disappointment to those who had cherished hopes for the success of the electric carriage which entered the lists. The result, so far as the electric carriage was concerned, might have been foreseen. We have never been accused of lukewarmness in advocating the adoption and application of electricity to any useful purpose suggested, but a consideration of all points involved leads us to the unavoidable conclusion that, for *long distances, such as those covered in the Paris-Bordeaux contest*, the electric storage battery carriage is not yet available. * * * It requires 250 pounds of battery and

† From the Secretary's monthly reports.

motor to produce one horse-power hour, and, handicapped in this fashion, it is useless to pretend that the storage battery can compete with power directly applied, by a prime mover weighing less than one-quarter of the necessary electrical equipment. Granted even that a lighter form of storage battery may make it possible to reduce the weight, even the copper-alkaline cells would hardly reduce the weight of battery more than one-third. We have, in the above comparison, considered the electric storage battery carriage in the light merely of a long-distance traveler; but while compelled to admit its inferiority under such conditions, we are by no means ready to concede like superiority for the petroleum motor for the ordinary distances, to cover which wagons are usually employed. After all, the French contest was a *tour de force*, and it is doubtful if any one, desirous of going from Paris to Bordeaux and return, on business, would dream of selecting the wagon-road instead of the steam railway. To that extent, therefore, it is necessary to modify the opinion which one is apt to form at the start. * * *

"The first consideration in modern travel is comfort, and this holds true as well for short as for long distances. It is this requisite, aside from the question of speed, which has made the stage-coach and omnibus a memory in most civilized countries, and has given the electric car the popularity it enjoys. Granted, then, the conditions of short haul (which is the normal work of a road carriage) and maximum comfort, we are not alarmed for the future of the electric carriage. On the contrary, comfort being the first consideration in vehicles of this type, the comparison, as between a heat engine of any description whatever, and the electric motor, becomes almost ludicrous. Far, therefore, from losing courage, those who are devoting their attention to the construction of electric carriages should redouble their efforts. The several recent designs of electric carriages actually constructed * * * give evidence of intelligent thought, and, with the improvements suggested by their operation in practice, we may soon expect the creation of a regular demand for such vehicles. Nor must it be forgotten that there are other means of electric propulsion to which ordinary road vehicles are well adapted, and that the trolley carriage, fed by current from overhead conductors, is by no means as remote as it would appear to be. Requiring no outlay whatever for track construction and repairs, rights of way, etc., a system of electric trolley carriages might in many instances be found profitable where a railroad would not pay. It may appear as a begging of the question to put forward the trolley carriage in a discussion of self-propelling vehicles, but we mention it merely to show that the methods at disposal for electrically-driven vehicles are by no means confined to the storage battery, while, naturally, the energy supply of all other types of carriages is limited to their fuel-carrying capacity.

"All indications point to a rapidly growing interest in vehicles of this class, an interest which is stimulated by the announcement of two new competitions—that organized by the *Times-Herald*, of Chicago, with $5,000 in prizes, and the other, by the London *Engineer*, which holds forth incentives in the shape of prizes aggregating 1,000 guineas. These competitions will enable American and English inventors to test their vehicles of this class, and will afford a useful means of comparison with those of French design."

DURFEE'S HYDRAULIC VACUUM PUMP AND BLOWPIPE.

Mr. W. F. Durfee, whose familiarity with the historical evolution of the mechanical arts is widely known to the readers of current engineering literature, in a recent impression of the *American Machinist*, gives a description of "that very ancient mechanism for 'raising the wind,' called a *trompe*," in connection with certain modified forms of compression and vacuum apparatus, based on the same general principle, which he devised in 1869. Of this article the following abstract may be of general interest. The *Journal* is indebted to the *American Machinist* for the use of the cuts.

Fig. 0 is a vertical section of one form of the trompe. The water which operates it discharges from supply pipe *A*, into the flared top of the vertical pipe *C*, which is furnished near its top with several inclined apertures e e_1, for the admission of air. In descending *C*, the water draws in air through these apertures, carrying it downwards into the closed chamber *D*, where the water

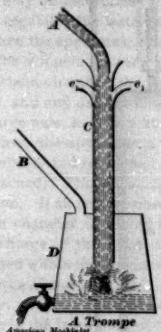


Fig. 0

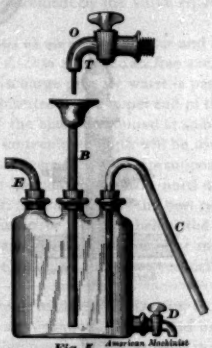


Fig. 5

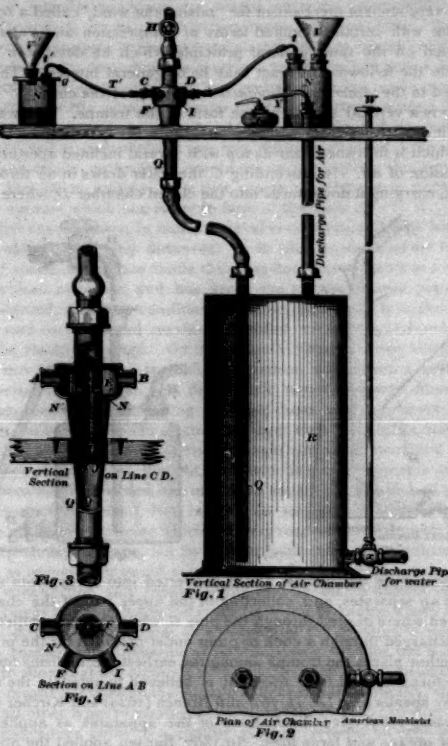
dashes upon some obstruction, and is converted into spray, from which the entangled air separates, and, collecting in the upper part of the chamber *D*, is conveyed where desired through the pipe *B*, while the water collects below and is discharged through a cock or other outlet provided for the purpose.

The author places the trompe among the earliest mechanisms for furnishing air to furnaces and forge fires. It is believed to antedate the Christian era. Pliny speaks of it (A. D. 76), and Branca (1629) and Kircher (*Mundus Subterraneus*, 1665) give illustrations of the apparatus as applied to the blowing of organs and forge fires. In 1867, Bunsen applied the principle in the construction of his well-known filter pump. Mr. Durfee, in 1869, designed what he believes to have been the first apparatus in which the two functions of the trompe—compression and vacuum—were combined.

Mr. Durfee's combined vacuum pump and table blowpipe will be understood from the following description with the aid of the cuts:

Fig. 1 is a general elevation, with air chamber sectional; *Fig. 2*, a plan of the air chamber; *Fig. 3*, a vertical section of the vacuum pump on line *C D*, of *Fig. 4*, which is a horizontal section on line *A B* of *Fig. 3*.

The vacuum pump is constructed of copper. The vacuum chamber *E* is



supported on the upper expanded end of pipe *Q*, and has four nozzles (*C*, *F*, *I*, *D*), *Fig. 4*, two of which are seen in section at *A B*, *Fig. 3*. *P* is the water supply pipe, at the lower end of which is an internal pipe *p*, communicating with the vacuum chamber, and supported by two elliptical nozzles *N N*. The upper end of pipe *P* is closed by a conical cap. The relative sizes of the

pipes *P* and *p* are such that an annular adjutage, one-sixteenth of an inch in thickness, is formed between their lower ends, through which the water from the supply pipe *P*, passes into pipe *Q*, drawing along with it any air that may be in the vacuum chamber *E* and upper conical part of pipe *Q*, the air in *E* having free access to the interior of the hollow cylindrical jet through the nozzles *N N* and the internal pipe *p*.

When the apparatus is to be used as a filter pump, one of the nozzles, *C, F, I, D*, is connected with the vessel to receive the filtrate, or several or all of them may be so connected and operated simultaneously. The several modes of making such connections and the construction of this air chamber are so clearly shown in the cut as to make more detailed description unnecessary, and it is scarcely necessary to notice that the orifices of the unused nozzles must be properly closed by stoppers when the pump is in operation, and the valve *x* in the discharge pipe for water kept open. The action of the pump may be controlled according to requirement by the valve *H*, *Fig. 1*, which regulates the water supply.

When the apparatus, *Fig. 1*, is to be used as an air compressor and blowpipe, the stoppers are removed from *C, F, I, D* to allow the air free access to the vacuum chamber, the valve *x* in the discharge pipe for water is partially closed, and any desired form of blowpipe inserted in the upper end of the air discharge pipe, as shown at *Y*, *Fig. 1*. If the blast is required at some distance from the apparatus, a rubber tube of convenient length will be used for the purpose, and to the end of this the blast tuyere, held in some support, will be attached. The *modus operandi* of the air compressor will need no description. It should be observed, however, that, to obtain the best results, the air chamber *R* should be located about 10 or 12 feet below the point of discharge of the blast. The volume and pressure of the blast may be regulated within the maximum limits by the suitable adjustment, respectively, of valves *H* and *x*.

Fig. 5 represents a form of trompe blowpipe made by Mr. Durfee, in 1863, for use in the laboratory of the steel works at Wyandotte, Mich., and has the advantage of being readily arranged with the means usually at hand in every laboratory. It is formed of a three-necked flask, fitted air-tight with the funnel tube *B* extending nearly to the bottom, with a siphon tube *C* (for which, when a two-necked flask is used, a cock *D* may serve) and with an outlet pipe *E*, for conveying the blast where it may be required for use. In service, this apparatus is placed beneath the hydrant cock *O*.

ELECTRICALLY-LIGHTED BUOYS IN THE GEDNEY CHANNEL, NEW YORK HARBOR.

London *Nature* has the following to say respecting the successful lighting of the Gedney Channel entrance to New York Harbor:

"A remarkable system of electric lights on buoys has just been completed at the Gedney Channel, off Sandy Hook. This channel is only 1,000 feet wide, and vessels have not, heretofore, been able to pass through it by night. The new system, however, provides a brilliant thoroughfare, lighted by ten

incandescent lights of 100 candle-power each, and each on a buoy, about fifty feet long, and rising twelve feet out of water. The cable which conveys the electricity carries the pressure of 1,000 volts under water, and is six and one-half miles long, being the longest cable in the world carrying a high-pressure current under water, and also the only one of its kind ever made. It consists of a copper conductor, insulated with gutta-percha, bedded in jute and sheathed with hard-drawn copper wire. The machines have an output of only 100 volts, but the current flows through a step-up converter, back of the switchboard, where it is converted into the required voltage, being thus perfectly safe to operate."

THE PHYSICAL PROPERTIES OF ARGON.

Lord Rayleigh, in a recent communication to London *Nature*, contributes the following data bearing on the chemical position of argon. The gas was prepared from atmospheric air with the aid of oxygen and alkali only:

"Weighings at 0° C. upon a large scale (two liters), and with the apparatus formerly employed for other gases, give, as the density of argon, ($O_2 = 16$)

19·940,

a number in almost exact agreement with that obtained by Professor Ramsay, working upon a relatively small scale, and with gas derived by magnesium (Rayleigh and Ramsay, *Phil. Trans.*, 1895).

"In spite of its greater density, the refraction ($\mu - 1$) of argon is only ·961 of that of air; so that if we take for air under standard conditions

$$\mu = 1{\cdot}0002923,$$

then for argon

$$\mu = 1{\cdot}000281."$$

PRIZE FOR ELECTRIC HEATERS.

It may interest American inventors to know that the German Hygienic Association offers a prize of $1,200 for a research essay on the efficiency of electric heaters. The programme is as follows: "The heat given out in heating installations by heaters in their various forms and modes of use is to be ascertained. The investigations are to be described in detail in respect to the arrangement of the heaters, the nature of the heating agents and the observations made; and they are to be illustrated by drawings. The heating values obtained are to be stated in units of heat given off per hour per unit of surface. In the case of heat given out to air, the investigations must be conducted with currents of air at speeds as different as possible. The heaters are to be described in detail as regards form and measurement, and the relation of their heating efficiency to their weight is also to be ascertained." Essays are to be written in German, and sent with a motto and sealed envelope to Prof. Konrad Hartmann, Charlottenburg, Fasannstrasse, 18, before July 1, 1896. The essay will remain the property of the successful competitor, but he is required to publish it within six months, and to give the prize offerers gratuitously 300 copies. The offerers reserve the right to divide or withhold the prize.

METALLIC SODIUM FROM LEAKAGE CURRENTS.

The curious observation, lately made in England, of the formation of metallic sodium as the result of the electrolytic action of leakage currents, has been duplicated by a similar observation recently made in Boston. The case in question formed the subject of a report by Messrs. Forbes & Glid en to the Boston Fire Underwriters' Union, and related to the examination of a substance found in the casing about the electric mains in the basement of the Pray building. The following abstract from the report is taken from *The Electrical World:*

"The substance discovered was in reality impure metallic sodium mixed with partially disintegrated wood, the metallic sodium being the product of an electrolytic decomposition of impure sodium hydrate. This sodium hydrate came from the cement mortar used in laying the brick wall of the basement, upon which the wires were supported. Some of the hydrate may have possibly worked its way through the wall from the cement used in the foundation of the paved street (Washington Street) immediately adjacent.

"The electric current which caused the electrolytic action was due to a leak inside the casing from one of the mains to another, the leak having been produced by the action of the sodium hydrate on the insulating covering of the wires. This covering was what is known as 'weather-proof,' consisting of a cotton braiding covered with tar, which material is readily attacked by sodium hydrate and its insulating properties destroyed. * * *

"Inside the casing the wires were partially covered by an insulating tubing consisting of tarred paper. * * *

"The wood at this point (*i. e.*, where the sodium was found. W.), was badly eaten and discolored by the caustic action of the sodium, and for some distance around, especially along the top of the casing, was soft and wet.

"For several months before the sodium was found, a slight smoke had been noticed to issue occasionally from the casing. When the front of the casing was removed, the wires, tubing and woodwork about this point were covered with a thick liquid, which had dried in places to a white substance resembling discolored salt and which was slippery to the touch and strongly corrosive. The metallic sodium was smoking, and, when moistened and struck with any hard material, gave off flashes of fire.

"The following tests were made shortly after the discovery of the deposit, upon which the explanation given above is based. The substance was determined to be mainly metallic sodium by its appearance and characteristic reactions, and by its color in the Bunsen flame. The sample upon which the test was made was about half wood partially disintegrated, adhering to which was a mass composed of white sodium hydrate on the outside, with the metallic sodium in the centre.

"Samples were taken from the surface of the wall at numerous points along the front of the basement, each of which gave a strong alkaline reaction. The moisture on the wall was also strongly alkaline.

"The insulation on the wires about the point where the sodium occurred was found to be practically destroyed. The upper two wires (negative) were

in the worst condition, the middle two (neutral) were nearly as bad, while the lower two (positive) had not been so much affected.

"The outer covering of tar, especially on the negative and neutral wires, had been dissolved by the action of the caustic, leaving the braiding bare and saturated with the sodium hydrate, which had dried white in places."

BOOK NOTICES.

Illustrated Catalogue and General Description of Improved Machine Tools for Working Metal. Designed and constructed by William Sellers & Co., Inc., Philadelphia, Pa., U.S.A. Philadelphia: Printed by J. B. Lippincott Company. 1895.

The publication above-named has been issued in place of a new edition of the well-known "Treatise on Machine Tools" of this Company. This was found to be impracticable, by reason of the numerous changes that have been made in the forms and details of its standard tools, and of the number of new and important special tools that have been added to the list of the company's productions.

It was decided, therefore, to begin *de novo*, and to illustrate the new publication in the best style of the modern art of half-tone engraving, which presents the double advantage of an attractive appearance, and of giving a faithful delineation of each machine.

The present book, substantially bound in boards, forming a volume 7½ x 7½ inches, superbly illustrated, and a model of typographic execution, is the result.

Coming now to the contents, a few pages are devoted to a description of the works, (which, without detracting from the interest of the catalogue, might have been made more elaborate), and the remaining 400 odd pages are given up to the various products of the establishment.

The arrangement of the text and the form and size of the book appear to have been decided upon after careful consideration of the objects to be subserved. The various products of the company are arranged in classes. The left-hand pages give a description of the general features of the tools illustrated in each class; while those on the right contain the photo-engraved pictures of the "standard" or "special" tools, with title and brief specifications, giving principal dimensions, salient operative features, etc. The purpose of this arrangement is explained in the introduction to be "to present to our customers a book which shall combine the advantages of an illustrated catalogue of tools, with brief specifications for quick reference, together with a general discourse for more leisurely examination. A further object in determining the size and shape of the book has been to assist the convenience of the reader; the aim being to show all the tools, whether upright or horizontal, in the same position on the page and to avoid unwieldy size, while at the same time presenting illustrations of sufficient dimensions to exhibit details

clearly." The form and arrangement of the catalogue are admirably adapted to realise these objects.

Following is a summary statement of the principal contents:

About a dozen pages are devoted to general introductory remarks, stating the purpose of the work and giving a somewhat meagre historical sketch of the establishment, with a few pictures of interiors of several of its departments. Then follow, in the order named, the bolt and nut screwing machines, vertical drill presses, rail drilling machines, universal drilling machines, radial drills, horizontal drilling and boring machines, and drills and boring machines for special purposes, such as locomotive cylinder boring and facing, vertical cylinder boring, pulley boring, car-wheel boring, etc. Then follow standard and special lathes, ranging from the mammoth machine for turning and boring 16-inch guns, down. Next come the well-known tool and drill grinders, milling machines, automatic gear-cutting and wheel-dividing machines, rotary planers, shaping machines, slotting machine planers, plate planing machines, punching and shearing machines, steam hammers, steam and hydraulic riveting machines, portable riveting machines, hydraulic accumulators, bending rolls, hydrostatic wheel presses, hoisting machines, electric cranes, swing cranes, car cranes, hydraulic cranes, traveling cranes. Under the latter head is given an illustrated description of the 150-ton electric traveling crane built for the Carnegie Steel Company, Limited. The following pages are devoted to railroad turn-tables, injectors and hydraulic testing machines (the last including the system of A. H. Emery, the designer of the Watertown Arsenal machine), shafting, embracing the various appliances for the mechanical transmission of power, and mechanical stokers.

A very full, analytical subject-index is given at the close. W.

A Discussion of the Prevailing Theories and Practices Relating to Sewage Disposal. By Wynkoop Kiersted, C.E., New York: John Wiley & Sons. 1894. (Price, $1.25.)

The author treats this important subject concisely and intelligently. After giving a summary of the theme in his introduction, he treats of sewage and sewerage; the vital process of purification, by which he means to indicate the natural process of purification by bacterial oxidation; then, in succession, the methods of sewage disposal by dilution, by irrigation, by intermittent filtration, and by chemical precipitation. A general discussion of the merits of the foregoing methods closes the volume, which is an excellent *résumé* of the whole subject in the light of the latest and best opinion.

W.

Antisepsis and Antiseptics. By Charles Milton Buchanan, M.D., etc. With an Introduction by Prof. Augustus C. Bernays. Newark, N. J.: The Terhune Company. 1895. (Price, $1.25).

This compendium has been prepared for the use of the physician, and seems to contain in concise form everything essential to give the medical

practitioner a clear and accurate account of the evolution of antiseptic medicine and surgery from its early origin to the present. The present state of the art is presented very fully, not only by the concise statement of the views of its most eminent living exponents, but also by the compilation of the rules of practice recommended and followed by the leading surgeons.

A particularly valuable portion of the work is the chapter on "Antiseptics and their Relative Value," in which is given a digest of the properties of all the antiseptic agents known and used to any extent in medicine. It impresses the reviewer as a work which would be found extremely useful in library of every physician. W.

The Ventilation of Mines. Designed for use in schools and colleges, and for the practical mining men in their study of the subject. By. J. T. Beard, C.E., E.M. New York: John Wiley & Sons. 1894. (Price, $2.50.)

So far as we are aware, this is the first attempt of an American author to present the data upon this important topic in such form as to be available for the needs of the student of mine engineering. The elaborate treatises of Fairley, Atkinson and others are at present the only sources of authoritative information on the subject, and these are not suited for the use of the student or the average mining engineer. The author develops his subject very systematically and thoroughly, and the book ought to serve a very useful purpose. A series of practical problems is given at the close of the book.

W.

Jahrbuch der Elektrochemie—Berichte über die Fortschritte des Jahres, 1894, bearbeitet von Dr. W. Nernst und Dr. W. Borchers. 1. Jahrgang. Halle a. S. Verlag von Wilhelm Knapp. 1895.

The great increase of activity that has been apparent within the past few years in the field of electro-chemistry, in its application to the arts and industries, affords ample evidence that the cultivation of this branch of applied science is attracting the attention of an ever-increasing body of investigators. Until lately this activity was confined largely to the metallurgical field, in which many notable advances have been achieved, as witness the electrolytic methods for the refining of crude copper, argentiferous lead, the production of aluminum, the thermo-electric methods of working metals and reducing refractory oxides, etc. More recently, the attention of investigators has been directed, with increasing interest, to the great possibilities which electrolytic methods open in the chemical arts and industries, and the past few years has witnessed astonishing developments in these directions. They have been applied and, in many cases, with highly successful results, to the disinfection of sewage, to the dyeing and bleaching of textile fabrics and fibers, to the tanning of skins, and to the production of a great number of chemical products, such as soda and bleach, the chlorates, etc. The field is only fairly opened as yet, and the next decade will doubtless witness a radical revolution in the

practice of many of the chemical industries, brought about by the introduction of electrical methods.

The progress in this branch of applied science has been so rapid that the need by students and investigators for reference literature has been sorely felt. It is being supplied, in part, by recently founded periodicals devoted to it, and the present "Yearbook" is the latest addition to the sources of information that are accessible. There has been and is a positive want for such a record, and the Yearbook of Nernst and Borchers promises to meet it admirably. It is systematically arranged, being divided into two parts—theoretical and applied, which in turn are intelligently sub-classified—and appears to be quite exhaustive. The student and technologist will find it a storehouse of facts of the highest value, and it should take its place as a standard reference work in its special field. Both editors are well-known authorities in their respective specialties.

The publisher has issued the book in excellent form. It is very well printed and illustrated. W.

Encyclopédie des Aide-Mémoire. Dirigée par M. Léauté, membre de l'Institut. Paris: Gauthier-Villars et fils et G. Masson. [Price, per volume (small 8vo.), paper, 2½ fcs. Cloth, 3 fcs.]

The following volumes of this encyclopædia have appeared since the last announcement in the *Journal*, viz.:

Witz, Ainé. Docteur ès Sciences, Professeur à la Faculté libre des Sciences de Lille. *Les Machines thérmiques.*

Laurent, H. Examinateur d'admission à l'École Polytechnique. *Théorie et pratique des Assurances sur la vie.*

Léauté, H. Membre de l'Institut, et Bérard, A. Ingénieur en chef des Poudres et Saltpêtres. *Transmissions par câbles métalliques.*

The reader is referred to earlier notices of this valuable publication which have appeared in our book columns. W.

The Mineral Industry: Its Statistics, Technology and Trade in the United States and other Countries, to the End of 1894. Vol. iii. Edited by Richard P. Rothwell. New York and London: The Scientific Publishing Company. 1895. (Price, $5.)

The third volume of this statistical, technological and trade review of the mineral industries forms a stately work of some 750 pages. We have stated in our review of previous volumes the unique advantages offered by the energy and enterprise of its able editor, in affording the professional engineer and the business man interested in mines and minerals, so promptly after the close of the year, the most reliable and complete information accessible respecting the subjects of which it treats. We have nothing—in this country, at least—which remotely approaches it in timeliness and comprehensiveness.

It would only be possible to accomplish a task of such magnitude with the

co-operation of a large staff of capable experts, and this aid the editor has been most fortunate in commanding from the beginning of his publication.

In considering the merits of the present volume of this important work, we find nothing to cause us to qualify the warm acknowledgment of its great value as a reference book to professional and business men interested in the mineral industry, which we have bestowed upon the earlier volumes. W.

Franklin Institute.

[*Proceedings of the stated meeting, held Wednesday, September 18, 1895.*]

HALL OF THE FRANKLIN INSTITUTE,
PHILADELPHIA, September 18, 1895.

JOS. M. WILSON, President, in the chair.

Present, sixty-eight members and eight visitors.

Additions to membership since last meeting, fifteen.

The Secretary, under instruction, reported a vacancy in the Committee on Science and the Arts, caused by the resignation of Mr. Clarence B. Schultz. The vacancy was filled by the election of Mr. John Haug for the unexpired term.

Mr. Robert Grimshaw presented an oral communication on a "Test of American Steam Snow-plows on the Prussian Military Railway at Mahlow," also a communication describing the "Improvement in Rail-Joints for Railways," devised by Prof. Koepcke. (To appear in the *Journal.*)

Mr. W. N. Jennings exhibited on the screen, and gave some account of, a series of photographs taken by himself, of the recent total lunar eclipse, which was visible in this locality, and which occurred under conditions extremely favorable for observation.

The Secretary's report included, among other matters, more or less extended descriptive references to the substitution of the electric locomotive on short lines of railway and for tunnel haulage; to the extensive system of subways now being constructed for passenger traffic in the city of Boston; to the recent trials, in France, of automobile carriages, and prospective trials of such vehicles to take place in November between Chicago and Milwaukee.

Adjourned.

WM. H. WAHL, *Secretary.*